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W. C. EBAUGH

Permanent Secretary Denison Scientific Association

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Articles 4-7, pp. 119-232; Dec., 1910 ..... $0.75

Standardization of well water in the vicinity of Granville, Ohio; Lily Bell Sefton. 5 pp.
Chapters on the geography of Ohio; F. Carney.
Transportation; 11 pp.
Economic mineral products; 47 pp.
Glaciation in Ohio; 48 pp.

Articles 8-12, pp. 233-346; April, 1911 ..... $0.75

The abandoned shorelines of the Vermilion Quadrangle, Ohio; F. Carney. 12 pp., 2 figs.
Thermo-electric couples; A. W. Davidson. 21 pp., 16 figs.
The Mercer limestone and its associated rocks in the Newark-Zanesville region; Clara G. Mark. 47 pp., 2 plate 5 figs.
A study of the supposed hybrid of the Black and Shinglecaks; Earl H. Foote. 15 pp., 4 plates.
A case of pre-glacial stream diversion near St. Louisville, Ohio; Howard Clark. 8 pp., 4 figs.

Articles 13-17, pp. 347-423; July, 1911 ..... $0.65

The Swasey Observatory, Denison University; Herbert G. Wilson. 5 pp., 4 figs.
The contribution of Astronomy to general culture; Edwin B. Frost. 12 pp.
The geological development of Ohio; F. Carney. 15 pp.
The relief features of Ohio; F. Carney. 13 pp., 1 fig.
Geographic conditions in the early history of the Ohio country; F. Carney. 20 pp.

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VOLUME XXIII

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DENISON SCIENTIFIC ASSOCIATION

Organized April 16, 1887

REPORT OF THE PERMANENT SECRETARY FOR THE YEAR 1927–1928

During the year 1927–1928 the Association was served by the following officers.

RICHARD H. HOWE, *President*
B. D. GREENSHIELDS, *Vice-President*
(Miss) MATTIE L. TIPPETT, *Secretary*
(Miss) MATTIE L. TIPPETT, *Treasurer*
M. E. STICKNEY, *Librarian*
W. C. EBAUGH, *Permanent Secretary and Editor*

In accordance with the usual custom, meetings were held on alternate Tuesday evenings, and addresses were given as follows.

October

ANCIENT CLIMATES—M. E. STICKNEY
DESERT LIFE—W. C. EBAUGH

November

RESEARCH IN BRITISH GUIANA—GEORGE MORGAN
STUDIES ON THE EVAPORATION OF CRYSTALS—EDWARD MACK, JR.

December

THE BLUE RIDGE OF THE SOUTH—FRANK J. WRIGHT

January

THE ACTIVATED SLUDGE SEWAGE DISPOSAL PLANT FOR THE SMALL TOWN—B. D. GREENSHIELDS
THE COMPTON EFFECT—C. D. COONS

February

MODERN GEOMETRY—ROWLAND A. SHEETS
COMMERCIAL AIR TRANSPORT—HIRAM L. JOME

March

THE GLORIES OF ANCIENT AMERICA—F. G. DETWEILER
RUNNING THE MAZE: RATS AGAINST MEN—T. A. LEWIS

April

THE SOCIAL INSECTS—A. W. LINDSEY

May

CONSTANTINOPLE: SEAT OF EMPIRE—EDGAR J. FISHER
THE INTERIOR CONSTITUTION OF THE STARS—PAUL BIEFELD
LIFE IN HAWAII—J. H. COMSTOCK

Three numbers of the JOURNAL OF THE SCIENTIFIC LABORATORIES OF DENISON UNIVERSITY were issued as follows:

Vol. XXII, Articles 5–9, pp. 137–193, October, 1927
Science and Religion (Address); Robert A. Millikan. 10 pp.
Forty Years of Scientific Thought Concerning the Origin of Life (Address); Kirtley F. Mather. 11 pp.
Darwin as a Pioneer in Evolution (Address); George A. Dorsey. 14 pp.
Science and Living (Address); C. Judson Herrick. 9 pp.
Founding of the Denison Scientific Association (Address); Alfred D. Cole. 6 pp.

Vol. XXIII
Articles 1–2, pp. 1–126, January, 1928
American Arctic and Related Cephalopods; Aug. F. Foerste. 110 pp., 29 plates
Apatodonosaurus, a New Genus of Ichthyosaurs from the Jurassic of Wyoming; M. G. Mehl. 16 pp., 2 figs., 6 plates

Articles 3–5, pp. 127–230, July, 1928

Some Brachiopods from the St. Clair Limestone, Arkansas. Norman L. Thomas. 13 pp., 1 plate

The Phytosauria of the Wyoming Triassic. M. G. Mehl. 32 pp., 9 figs., 3 plates.

A Restudy of some of the Ordovician and Silurian Cephalopods described by Hall. Aug. F. Foerste. 58 pp., 8 plates.

Respectfully submitted,

W. C. EBAUGH, *Permanent Secretary*

HESPERIOIDEA FROM THE KARTABO DISTRICT OF BRITISH GUIANA

A. W. LINDSEY

Received October 25, 1928; published December 31, 1928

During the summer of 1925 Mr. George D. Morgan, now of the department of zoölogy in Denison University, spent several weeks in the vicinity of Kartabo, British Guiana, with headquarters at the jungle laboratory established by Mr. William Beebe. In spite of the demands of his own work Mr. Morgan found time to contribute generously to the needs of others, and it has been my privilege to examine a small collection of Hesperioidea which he secured. My heartiest thanks are due him for this material.

The collection includes a number of common species of wide distribution which are to be expected in any lot of tropical American skippers, but in addition it contains specimens which have enabled me to establish the validity—as well as the identity—of one more of Plötz's species and to furnish figures of the genitalia of several other little-known species. Every such contribution brings us a step nearer the completion of the vast amount of work which must precede the accurate classification of the neotropical Hesperioidea.

The localities mentioned are within a relatively small area, none of them remote from Kartabo. The species are as follows:

PYRGINAE

Owing to the action of the International Commission on Nomenclature in casting out Hübner's *Tentamen*, the name *Urbanus* Hbn. cannot replace *Hesperia* Auct., as I once suggested, and the subfamily name *Urbaninae* which I proposed to supplant the name *Hesperiinae* of common usage must be replaced by the name *Pyrginae*.

1. **Goniurus stylites** H.-S. Puruni Trail, July 30 and Aug. 2, 1 ♂ each. I have examined the genitalia of both specimens and find that the penis bears a

cluster of spines instead of the two spines illustrated by Williams in the Trans. Am. Ent. Soc. LII, 75, fig. 18. I am unable at present to determine the significance of this discrepancy.

2. **Goniurus brachius** Geyer. Camaria, July 24, 1 ♂; Puruni Trail, July 9, 1 ♂. This species has been repeatedly confused with *nivosus* Plötz and *doryssus* Swainson, although the three are abundantly distinct. I have before me as I write a specimen which agrees closely with Swainson's figure of *doryssus*,

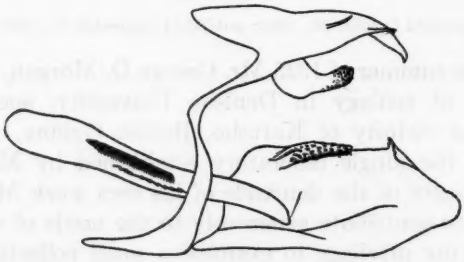


FIG. 1

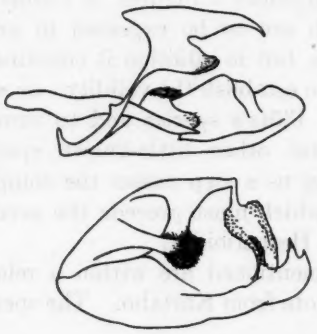


FIG. 2

one which I have identified as *nivosus* Plötz, and several of *brachius* Geyer. The first two are females, hence I am unable to give data on genitalia. The genitalia of my specimens of *brachius* resemble those of *albimargo* Mab. as figured by Williams (Trans. Am. Ent. Soc. LII, 67, fig. 3), but superficially my specimens bear no resemblance to the figure of *albimargo* published by Mabille and Vuillot (Nov. Lep. pl. V, fig. 2). The genitalia are also unlike those of *doryssus* figured by Williams (Trans. Am. Ent. Soc.

LII, p. 67, fig. 1). My *brachius* resembles William's figure of *tenuis* Williams (Trans. Am. Ent. Soc. LIII, pl. XXV, fig. 2), which I cannot regard as a form of *doryssus* on the basis of the published characters. I am unable to modify the conclusion expressed in a former issue of this Journal (Vol. XXI, 75), where a summary of the distinctive characters of the three species is given.

3. **Goniurus decurtatus** H.-S. Mazaruni Trail, Aug. 14, 1 ♀.
4. **Telemiades phasias** Hew. Fig. 1. Mazaruni Trail, July 18, 1 ♂.
5. **Bungalotis ramusis** Cram. Puruni Trail, July 7, 1 ♀.
6. **Cecrops itylus** Hbn. Kalacoon, July 4, 1 ♂; Mazaruni Trail, July 25, 1 ♂.
7. **Entheus peleus** Linn. Puruni Trail, July 10, 1 ♀; Mazaruni Trail, July 18, 1 ♂; Camaria, July 24, 1 ♂.
8. **Quadrus cerialis** Cram. Kartabo, June 22, 1 ♂.
9. **Xenophanes tryxus** Cram. Baracara, July 11, 1 ♂.
10. **Sostrata pusilla** G. & S. Fig. 2. Baracara, July 12, 1 ♂.
11. **Ate jovianus** Cram. Penal Settlement, June 27, 1 ♂.
12. **Camptopleura tisias** G. & S. Puruni Trail, July 10, 1 ♀.
13. **Mionectes infernalis** Mösch. Puruni Trail, July 7, July 30, 1 ♂ each.
14. **Paramimus scurra** Hbn. Kartabo, July 6, 1 ♀.

FIG. 3

HESPERIINAE (Pamphilinae Auct.)

15. **Problema morgani** n. sp. Fig. 3.

Expanse 33 mm.

Upper surface blackish brown with yellow-fulvous markings. The head, body, and bases of the wings have some yellow-fulvous scales and hairs mixed with the darker vestiture and the basal portion of the antennal club is similarly colored. The under surface is chiefly pale dull yellow, the palpi alone with a sprinkling of black scales.

The fore-wings have the extradiscal band complete. The first spot is a small one between R_3 and R_4. The next two spots are much larger and those opposite to the cell again small. The spot between M_3 and Cu_1 is an elongate triangle, set basad of the preceding spot and extending in a sharp tooth along Cu_1 for a short distance. The spot between Cu_1 and Cu_2 is large and quadrate, with a concave outer margin. The spot between Cu_2 and A is oblique, sinuate within and concave without. A more hairy yellow-fulvous spot follows this band and extends toward the base of the wing along the inner margin. There is a small spot in the cell at the base of

Cu_1. The fringes are yellow-fulvous around the anal angle. The stigma is brownish gray and is made up of three parts. The first begins just beyond the base of Cu_1 and behind that vein. It runs along Cu_1 about half way to Cu_2 and there curves gently away from the cell, widening gradually as it curves, until it terminates at Cu_2. It is separated by Cu_2 from a small oblong spot. Directly between this spot and the inner margin there is a rounded spot against the anal vein. The last two spots lie in the space between Cu_2 and A and are separated by an interval about equal to the width of the oblong spot. The hind wings bear a yellow-fulvous band which begins just behind the radial, removed from the outer margin by about its own width, a millimeter, and runs parallel to the margin to a point between M_1 and M_2. Here it bends sharply toward the base of the wing. It runs to the first anal, widening and diverging from the outer margin. Its basal margin is somewhat irregular and its outer margin is concave between veins, with short teeth extending along the veins. Along 1st A the tooth is prolonged as a slender line to the margin. Fringes yellow-fulvous.

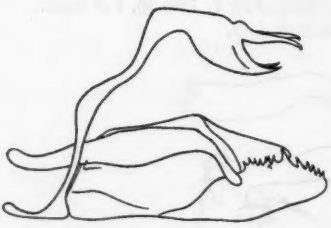


FIG. 4

FIG. 5

The under surface of the primaries is chiefly yellow, due to the extension of this color along all veins from the spots to the outer margin, and throughout the costal area. The same extension makes the hind wings yellow with a suggestion of brownish shades between the veins and a few diffuse brown submarginal spots between the veins from M_3 to 1st A. The last is elongate and has a few black scales. There are three black marginal dots at the ends of M_3, Cu_1 and Cu_2.

Holotype male, Puruni Trail near Kartabo, British Guiana, Aug. 2, 1925, in the collection of A. W. Lindsey. Named for the collector, Mr. George D. Morgan.

It is with some misgivings that I assign the smaller South American Hesperioidea to genera. This species is superficially not unlike our North American *arpa* and *byssus*, but the stigma is very different from that of *arpa*. While we may admit to the same genus species with and without secondary sexual characters, it seems illogical to include species in which the same type of stigma has attained different development. Skinner and William's separation of *byssus* in the new genus *Problema* from the species with which I had regarded it as congeneric suggests that the species has

fundamental differences. I find that *morgani* agrees with it in enough superficial points and details of genitalic structure to warrant at least a tentative association of the two species.

16. **Prenes evadnes** Cram. Kartabo, July 30, 1 ♀.
17. **Thoon taxes** G. & S. Fig. 4. Mazaruni Trail, Aug. 2, 1 ♂.
18. **Papias microsema** G. & S. Penal Settlement, June 30, 1 ♂.
19. **Euroto micythus** G. & S. Puruni Trail, June 22, 1 ♂; Kalacoon, July 4, 2 ♂.
20. **Metiscus? huaynai** Lindsey. Kartabo, July 20, 1 ♀. This specimen proves the tentative placing of the species in *Metiscus* to be incorrect, for it has no spines on the mid tibiae and the third joint of the palpi is not conspicuously short. Without a male I am unable to reach a satisfactory conclusion regarding its generic position.
21. **Mnasitheus simplicissimus** H.-S. Mazaruni Trail, Aug. 6, 1 ♂; Kartabo, July 6, 1 ♂, Aug. 2, 1 ♀.
22. **Vehilius venosus** Plötz. Camaria, July 22, 1 ♀; Puruni Trail, July 30, 1 ♀; Mazaruni Trail, Aug. 2, 1 ♀.
23. **Megistias corticea** Plötz (*epiberus* Auct.) Kartabo, June 24, 2 ♂; June 30, 2 ♂. The synonymy was noted by Godman, Ann. & Mag. Nat. Hist. (7) XX, 143, 1907.
24. **Megistias tripunctata** Latr. Kartabo, June 22, 1 ♂; Mazaruni Trail, Aug. 14, 1 ♂.
25. **Vorates decorus** H.-S. Puruni Trail, June 21, 1 ♀; Aug. 2, 1 ♂; Kartabo, July 30, 1 ♀ (at light!), July 6, 1 ♂.
26. **Vinius nicomedes** Mab. Puruni Trail, Aug. 2, 1 ♂.
27. **Padraona epictetus** Fab. Kartabo, July 2, 1 ♀; Aug. 2, 1 ♀.
28. **Padraona eudesmia** Plötz. Fig. 5. Puruni Trail, July 29, 1 ♂, 1 ♀.

    I have this species also from Yurimaguas, Peru, March. It is much like *epictetus* in superficial appearance, hence the confusion of the two names by Godman in his report on Plötz's species is not surprising. There is, however, a distinct difference in general habitus and abundant genitalic difference.
29. **Carystus laurea** Hew. Bartica Trail near Kartabo, July 1, 1 ♂.
30. **Carystus calvina** Hew. Puruni Trail, July 7, 1 ♂.
31. **Methionopsis modestus** G. & S. Puruni Trail, July 10, 1 ♂.
32. **Mnestheus ludens** Mab. Puruni Trail, June 21, 1 ♀. The spots are pale but otherwise the characters are exactly those of *ludens*.
33. **Perichares corydon** Fab. Kartabo, June 21, 1 ♂; July 9, 2 ♀.

A RESTUDY OF AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

AUG. F. FOERSTE

Received October 31, 1928; published December 31, 1928

The present paper continues the restudy of cephalopods, most of which were described more than sixty years ago. The species here selected for study are almost all Silurian orthoconic forms, chiefly orthoceroids, but also a few actinoceroids. To these are added a few Ordovician and Silurian species previously studied, several of which are cyrtoceroids.

The purpose is to place on record the information that can be secured from the types of previously described species, to state what essential information some of these specimens fail to produce, and to determine as far as possible where these species belong in our present system of nomenclature.

It is obvious that the value of cephalopods for the close correlation of stratigraphical horizons depends altogether on our success in discriminating closely similar forms. In those species in which not even the most elementary knowledge of the structure of the siphuncle is at hand, the opportunities for error are great. In such cases sometimes it is not possible even to determine the genus with accuracy. Hence it becomes important to learn at least what information can be secured from the type of each species already described, and to endeavor to supplement this information by a study of additional specimens.

In the course of this study it has become increasingly certain that many so-called descriptions have little diagnostic value in themselves. Where the types have been lost, and no figures were published, it often is impossible to determine with confidence exactly what species was described. Indeed, when the figure has not been carefully prepared, nothing but the type itself will serve. A study of some of the figures offered as illus-

trations of species leaves the student very pessimistic as to the value of such illustrations for the discrimination of closely related species. This emphasizes still further the great importance of preserving the types in some museum where their preservation is in reliable hands. To those who do not have access to the types, adequate illustrations are absolutely necessary. The number of American cephalopod species that have not yet been figured, according to Bassler's Index, exceeds 90, not including those that have been figured since the publication of this Index. If to this list be added those inadequately figured and inadequately described, it is evident that much remains to be done in order to bring our knowledge of species already described to a point where these species will be very serviceable in the exact correlation of closely related strata.

The present paper is intended as a contribution toward clearing up our knowledge of previously described species. The effort has been only partially successful. In some cases it was impossible to secure any knowledge of the structure of the siphuncle, or even where it was located. In others nothing is known of the relative number of camerae present in a length equal to the diameter of the conch. And in still others nothing could be discovered regarding the character of the surface of the shell. However, it is hoped it will prove of some assistance to record merely what information is *not* available, in the hope that this may lead to the discovery of additional specimens from which the information desired may be obtained.

As heretofore, the specimens studied have chiefly been borrowed from various institutions. These include the U. S. National Museum, Walker Museum at the University of Chicago, American Museum of Natural History, Museum of Comparative Zoölogy at Harvard Universiry, Wilmington College, Ohio State University, Illinois State Museum of Natural History, University of Illinois, private collection of Prof. T. E. Savage, Public Museum of Milwaukee, Wittenberg College, New York State Museum of Natural History, the Geological Survey of Canada, and the British Museum of Natural History. To the curators of all of these institutions the writer is greatly indebted and here expresses his appreciation of the favors received.

LIST OF SPECIES DESCRIBED

1. Orthoceras alienum Hall
2. Orthoceras alienoides Foerste
3. Orthoceras moodiense Foerste
4. Orthoceras shatzeri Foerste
5. Orthoceras rectum Worthen
6. Orthoceras whitfieldi Foerste
7. Orthoceras subbaculum Meek and Worthen
8. Orthoceras byronense Foerste
9. Orthoceras sp. (Cedarville)
10. Orthoceras wilmingtonense Foerste
11. Orthoceras penicillum Foerste
12. Sactoceras sp. (Cedarville)
13. Geisonoceras laphami (McChesney)
14. Geisonoceras wauwatosense (Whitfield)
15. Geisonoceras crebristriatum (Meek and Worthen)
16. Geisonoceras wortheni Foerste
17. Geisonoceras rochesterense Foerste
18. Geisonoceras franklinense (Miller)
19. Elrodoceras indianense (Miller)
20. Elrodoceras abnorme (Hall)
21. Elrodoceras cf. abnorme (Hall)
22. Elrodoceras cedarvillense Foerste
23. Elrodoceras sp. (Wilmington)
24. Elrodoceras (?) carmani Foerste
25. Elrodoceras (?) crebescens (Hall)
26. Cycloceras niagarense (Hall)
27. Cycloceras brucense (Williams)
28. Cycloceras jolietense Foerste
29. Cycloceras austini Foerste
30. Cycloceras semotior Foerste
31. Cycloceras junciforme Foerste
32. Cycloceras sp. (Port Byron)
33. Leurocycloceras raymondi Foerste
34. Leurocycloceras wisconsinense Foerste
35. Dawsonoceras hyatti Foerste
36. Dawsonoceras nodocostatum (McChesney)
37. Dawsonoceras graftonense Foerste
38. Dawsonoceras bridgeportense Foerste
39. Dawsonoceras americanum (Foord)
40. Dawsonoceras multiliratum Foerste
41. Spyroceras ruedemanni Foerste
42. Spyroceras gorbyi (Miller)
43. Spyroceras crocus (Billings)
44. Spyroceras tenuiannulatum (Hall)
45. Kionoceras scammoni (McChesney)
46. Kionoceras sp. (Yellow Springs)
47. Kionoceras sp. (Shelby)
48. Kionoceras woodworthi (McChesney)
49. Kionoceras lineolatum (McChesney)
50. Kionoceras loxias (Hall)
51. Kionoceras strix (Hall and Whitfield)
52. Kionoceras cf. strix (Hall and Whitfield)
53. Kionoceras delphiense (Kindle and Breger)
54. Kionoceras mcchesneyi Foerste
55. Kionoceras multiseptatum Foerste
56. Kionoceras myrice (Hall and Whitfield)
57. Kionoceras sp. (Port Byron)
58. Kionoceras austini Foerste
59. Kionoceras carltonense (Whitfield)
60. Kionoceras orus (Hall)
61. Kionoceras sp. (Huntingdon)
62. Kionoceras hoyi (McChesney)
63. Kionoceras fililineatum Foerste
64. Kionoceras rochesterense Foerste
65. Protokionoceras crooki Foerste
66. Protokionoceras medullare (Hall)
67. Protokionoceras striaelineatum (McChesney)
68. Protokionoceras sp. (Joliet)
69. Parakionoceras originale (Barrande)
70. Murrayoceras murrayi (Billings)
71. Offleyoceras arcticum (Foord)
72. Probillingsites welleri Foerste
73. Probillingsites williamsportensis (Foerste)
74. Ulrichoceras beloitense Foerste.

NEW GENERA

LEUROCYCLOCERAS; genotype, *Leurocycloceras raymondi* Foerste.
PARAKIONOCERAS; genotype, *Orthoceras originale* Barrande.
OFFLEYOCERAS; genotype, *Orthoceras arcticum* Foord.
PROBILLINGSITES; genotype, *Probillingsites welleri* Foerste

1. Orthoceras alienum Hall

Plate LXVII, fig. 4; plate LI, figs. 4, 5

Orthoceras alienum Hall, 20th Rep. New York State Cab. Nat. Hist., 354 (1868); rev. ed., 414, pl. 24, fig. 6, 7 (1870).

Under this name Hall figured both a living chamber and part of a phragmacone. Only the living chamber has been preserved, and the fragment of the phragmacone appears lost. Hence the living chamber here is selected as the type. It is not known that the phragmacone belongs to the same species as this living chamber.

That part of the living chamber which is preserved is 100 mm. long. Its diameter enlarges from 41 mm. at the base to 47 mm. at a point 75 mm. farther up, the apical angle equalling nearly 5 degrees. The specimen is a cast of the interior of the living chamber, and this cast contracts at a point 75 mm. above the suture of the septum at its base from 47 mm. to 43 mm., and then slowly enlarges to 45 mm. at a point 97 mm. above the suture. It probably continued to enlarge as far as the aperture which is estimated to have been 10 mm. farther up. This contraction is not a specific feature, as apparently thought by Hall, but is merely the annular constriction due to thickening of the inner side of the shell a short distance below its aperture. This constriction of the interior of the living chamber is found in many orthoceroids, especially in fully mature specimens, and it appears to have been merely one of several devices connected with the attachment of the animal to its conch. The presence of this contraction of the interior of the living chamber in *Orthoceras alienum* is diagnostic only in one respect; namely, it indicates that the living chamber of this species was only of moderate length, compared with the diameter at its base. The

cast of this living chamber is marked by faint obscure transverse undulations, which curve downward on the side assumed to be ventral. The same direction of slope is shown by the lower margin of the abrupt constriction near the top of the chamber. However, the suture of the septum at the base of the chamber slopes in the opposite direction. Under favorable illumination extremely faint vertical markings are seen, of which 5 occur in a width of 19 mm., suggesting the possibility of 30 within the circumference of the conch. Both the transverse and vertical markings are too faint to indicate the presence of similar, but more strongly defined markings on the exterior of the shell.

Locality and horizon.—Racine, Wisconsin; in the Racine dolomite. No. 2103, American Museum of Natural History.

Remarks.—This conch apparently is a true *Orthoceras;* every effort to use the obscure vertical markings as an indication of relationship to some species of *Protokionoceras* has failed, no species of this group being known with a similar rate of enlargement of the conch, and a similar length of the living chamber.

Phragmacones.—In association with the living chamber described above Hall figured a phragmacone estimated at 35 mm. in diameter, and to have had a little more than 4 camerae within a corresponding length. The siphuncle was central in location and about 6.5 mm. in diameter. Its segments were cylindrical in form. This fragment probably was referred to the same species as the living chamber merely because it came from the same quarry.

The nearest approach to a phragmacone of this type known from strata of about the same horizon is the specimen represented by figure 5 on plate LI. Its apical angle varies from 6 degrees along the lower half of the specimen to 5 degrees farther up. The number of its camerae within a length equal to the diameter of the conch varies from 5 at the base of the specimen to 4 at its top, the diameter at the top being 34 mm. The specimen represented by figure 2 on the same plate appears to continue the phragmacone up to a point where its diameter is 38 mm. and where the number of camerae in a length equal to the diameter is only three and a half. There is no indication on this second specimen

that its conch was fully mature, since there is no shortening of the uppermost camerae compared with those immediately beneath. If this enlargement of the length of the camerae, accompanied by a corresponding reduction in their number in a length equal to the diameter of the conch, is characteristic of the species it may be possible eventually to identify the phragmacone with some type of living chamber, but whether the latter will prove to be similar to the living chamber figured by Hall under the name *Orthoceras alienum* is uncertain. The two phragmacones represented by figures 4 and 5 on plate LI are from Bridgeport (Chicago), Illinois: in the Racine dolomite, and are numbered 23105 and 21892 respectively in Walker Museum, Chicago University.

2. **Orthoceras alienoides** Sp. nov.

Plate LI, figs. 1, 2; plate LXXV, fig. 8

Phragmacone 75 mm. long, enlarging at an apical angle of 4 degrees from a diameter of 26 mm. at its base to 31 mm. at its top. The number of camerae in a length equal to the diameter of the conch varies from 5.6 at the base of the specimen to 5 near its top, but the last 3 camerae are successively shorter, indicating that the animal had entered on its gerontic stage.

Living chamber nearly 110 mm. long, enlarging at an apical angle of 5 degrees from a diameter of 32 mm. at its base to 40 mm. at its top. Between 5 and 28 mm. from its top this chamber is slightly but distinctly contracted along its interior, as shown by the cast of the latter. The siphuncle at the base of the chamber is central in location and about 5 mm. in diameter.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection, in the U. S. National Museum.

Remarks.—These two specimens are closely similar to *Orthoceras alienum* Hall, from the Racine of Wisconsin and Illinois. The phragmacone differs in its relatively more numerous camerae, and in the latter decreasing in number, instead of increasing, toward the top of the specimen. The living chamber is relatively more slender.

In this case also it is uncertain whether the living chamber and phragmacone belong to the same species, but both were found in the same quarry and in the same horizon.

3. **Orthoceras moodiense** Sp. nov.

Plate LII, fig. 1

Specimen 130 mm. long, enlarging at an apical angle of 8 degrees, from a diameter of 21 mm. to 39 mm. in a length of 120 mm. The number of camerae in a length equal to the diameter of the conch decreases from 4.25 at the lower end of the specimen to 3.5 at its top. The concavity of the septa is relatively small. The siphuncle is central in location. The passage of the siphuncle through the septum is 3.5 mm. where the diameter of the conch is 20 mm., but nothing is known of the structure of this siphuncle.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

Remarks.—*Orthoceras moodiense* is distinguished from the other orthoceroids here figured from the Cedarville dolomite of Ohio chiefly by its apical angle, and the relative number of its camerae within a length equal to the diameter of the conch. These camerae are subequal in length along the upper four-fifths of the length of the specimen, notwithstanding the relatively rapid increase in the diameter of the conch.

4. **Orthoceras shatzeri** Sp. nov.

Plate LII, fig. 2

Specimen 123 mm. long, enlarging at an angle of 11 degrees, from a diameter of 26 mm. at its smaller end to 44 mm. at the base of the living chamber, 92 mm. farther up. The number of camerae within a length equal to the diameter of the conch decreases from 8.3 at the lower end of the specimen to 6.75 at the upper end of the phragmacone, the last or uppermost camera being conspicuously shorter than those immediately beneath, thus indicating that the animal was entering on its gerontic stage. The siphuncle is slightly excentric in location. Nothing definite

is known of its structure but it appears to have been of small size.

Locality and horizon.—Cedarville, Ohio; in the Cedarville dolomite. Named in honor of Prof. C. G. Shatzer of Wittenberg college.

Remarks.—This specimen is characterized by its large apical angle, and by the relatively small length of its camerae at earlier stages of growth.

5. **Orthoceras rectum** Worthen

Orthoceras rectum Worthen, Geol. Surv. Illinois, 6, 504, pl. 26, fig. 3 (1875).

Since the type is lost, our knowledge of this species in confined to such information as is provided by the published figure cited above, and by the following brief original description.

> Shell of medium size, very gradually tapering, septa moderately concave, two of the intervals being a little less in width than the diameter of the shell. Length of specimen, with twelve septa preserved, 8.87 inches (105 mm.); length of outer chamber about 3 inches (76 mm.). Surface markings and siphuncle unknown. This shell seems to be nearly related to *O. crebescens* of Hall, but differs from that species in its much less tapering form, and in the proportional width of the septa. *Locality and position:* Joliet, Illinois, in the Niagara limestone, Upper Silurian.

In the figure cited, the apical angle is 5 degrees. The camerae average about two and a half or slightly more in a length equal to the diameter of the conch. It is doubtful whether the type, if still preserved, would add anything to our knowledge of the species, beyond that presented by the published figure and description. Unfortunately, in the absence of any trace of the surface ornamentation it is not possible to determine whether this species is a typical *Orthoceras*, or belongs to some other orthoceroid genus, such as *Geisonoceras*.

6. **Orthoceras whitfieldi** Sp. nov.

Plate L, figs. 1, 4, 2, 3

Orthoceras crebescens Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 148, pl. 9, fig. 2 (1875).

Conch enlarging very slowly, the diameter increasing at the

rate of 7 mm. in a length of 100 mm., the diameter at the top being 49 mm. Four camerae occupy a length of 72 mm., which is equivalent to about 2.6 camerae in a length equal to the diameter of the conch. The concavity of the septum at its base equals 15 mm. The siphuncle is nearly central in location, and its diameter is 10 mm. where passing through the septa, enlarging scarcely 1 mm. within the camerae. The surface of the shell appears to have been smooth, as far as can be determined from the cast of the interior of the conch. Plate L, figs. 1, 2.

The diameter of the second specimen from the same quarry is 55 mm., and there are 3 camerae in a length of 45 mm., equivalent to 4 camerae in a length equal to the diameter of the conch. The concavity of the septa equals 14 mm. The siphuncle has a diameter of 11 mm. where it passes through the septa, enlarging to 12 mm. within the camerae. The lower margin of each septal funnel extends downward for at least 1 mm. Plate L, fig. 3.

The specimen figured by Hall and Whitfield from Cedarville, Ohio, under the name *Orthoceras crebescens* agrees closely with the second specimen in diameter and in the length of its camerae. Its rate of enlargement was about 5 or 6 mm. in a length of 100 mm. The siphuncle, moreover, is figured as having a diameter of 13 mm., which is only moderately larger than the diameter of the second specimen here described.

Locality and horizon.—Figures 1 and 3 represent specimens from the Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite; the first belongs to the Welch collection in Wilmington College; the last to the Austin collection in the U. S. National Museum. The specimen figured by Hall and Whitfield is numbered 3423 in the museum of Ohio State University.

Remarks.—*Orthoceras whitfieldi* is similar to *Orthoceras rectum* Worthen from the Joliet dolomite at Joliet, Illinois, but nothing is known about the siphuncle of the latter, and the Joliet species appears to be smaller.

A characteristic specimen of *Orthoceras whitfieldi*, with the siphuncle exposed, was found in the Hawthorne quarries, in the western part of Chicago, in the Racine formation.

7. **Orthoceras subbaculum** Meek and Worthen

Plate XLIX, fig. 1

Orthoceras subbaculum Meek and Worthen, Proc. Acad. Nat. Sci. Philadelphia, p. 256 (1865).

Specimen large, consisting of a living chamber 180 mm. long, and a phragmacone 255 mm. long. The latter enlarges 8 mm. in a length of 100 mm. At the base of the living chamber the larger diameter is 69 mm. and the smaller diameter is only 49 mm. The conch evidently was compressed after the death of the animal. The phragmacone includes 11 camerae. The latter number 3 in a length equal to the diameter of the conch at the top of the series counted near the base of the specimen, diminishing to 2.5 toward the top of the phragmacone in a corresponding length. The septa appear to be strongly concave. Nothing is known of the siphuncle, nor of the surface ornamentation of the shell. The interior of the shell of the living chamber was thickened in an annular manner a moderate distance beneath the margin of the aperture; this thickening appears on a cast of the interior of the chamber as a band-like contraction, the maximum contraction being 48 mm. from the aperture of the chamber. The amount of this contraction slightly exceeds 1 mm. on both sides of the specimen.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. Type, no. 7771, Illinois State Museum of Natural History.

Remarks.—In the absence of any knowledge of the character of the surface ornamentation of the type of this species it can not be determined whether it is a typical *Orthoceras*, or should be referred to *Geisonoceras*, *Protokionoceras*, or some other one of the various recently established orthoceroid genera. *Orthoceras rectum*, also described from Joliet, Illinois, but at a later date, differs chiefly in its smaller size, but since the type of that species is not known to be mature, its smaller size may be merely an indication of youth. *Orthoceras subbaculum* enlarges at about the same rate as the specimen of *Geisonoceras* figured on plate LXVI. The latter also was found at Joliet, but if the lower 44 mm. of its

length was occupied by only 2 camerae, then it became mature at a distinctly smaller size than *Orthoceras subbaculum*. *Protokionoceras medullare*, from the Racine of Wisconsin, has camerae of similar height, but it enlarges more rapidly.

8. **Orthoceras byronense** Sp. nov.

Plate LI, figs. 3 A, B

Specimen 34 mm. long, enlarging at an apical angle of nearly 10 degrees. Cross-section circular. The number of camerae in a length equal to the diameter of the conch equals about 2. The concavity of the septum at the base of the specimen is 5 mm. The siphuncle is central in location. At its passage through the septum at the base of the specimen its diameter is 1 mm.

In a second specimen, the length of the uppermost camera is sufficient to equal 2.2 camerae in a length equal to the diameter of the conch, but, immediately below, 3 camerae occupy a corresponding length.

Port Byron, Illinois; in the Port Byron member of the Niagaran. Nos. 447 and 467 in the U. S. National Museum.

9. **Orthoceras** sp. (Cedarville)

Plate LXXIV, fig. 2

Specimen 90 mm. long, consisting of a living chamber 70 mm. long, and of 2 camerae. The upper camera is 9 mm. long, and the lower one is 11 mm., so that the conch may be regarded as fully mature. The specimen enlarges from a diameter of 56 mm. at its base to 62 mm. at a point 62 mm. farther up, or at an apical angle of 5 degrees or possibly less. The living chamber is distinctly contracted from a point 48 mm. above its base almost as far as the aperture. The amount of this contraction varies from 1.5 mm. to 2 mm. along different parts of the circumference of the conch. If the lower of the 2 camerae still attached to the living chamber represents the average length of the camerae along the upper part of the phragmacone, then the number of these camerae in a length equal to the diameter of the conch is approximately 5. The concavity of the septa is 12 mm. Noth-

ing is known of the siphuncle nor of the ornamentation of the surface of the shell.

Locality and horizon.—Cedarville, Ohio; in the Cedarville dolomite.

10. **Orthoceras wilmingtonense** Sp. nov.

Plate LXXIII, figs. 3 A, B; plate LXXIV, figs. 1 A, B

Specimen 55 mm. long, depressed dorso-ventrally, enlarging laterally from a diameter of 23.5 mm. at its base to 31 mm. at a point 45 mm. farther up. The dorso-ventral diameters are about four-fifths as long as the lateral ones. Living chamber nearly 35 mm. long. Its upper part is strongly constricted along its interior from a point 18 mm. above its base to the top of that part which still is preserved, the maximum constriction being between 23 and 24 mm. above its base. The amount of this constriction is scarcely 1 mm. on either side of the conch. This constriction probably was confined to the interior of the conch, the surface of the shell probably not being constricted in any way. The sutures of the septa slope downward from the dorsal toward the ventral side of the conch at an angle of about 8 degrees with the horizontal along the upper part of the phragmacone. About 5.5 camerae occur in a length equal to the lateral diameter of the conch at the top of the series counted. The concavity of the septa is scarcely 5 mm. where the lateral diameter is 25 mm. The siphuncle is 1 mm. in diameter where it passes through the septum, but nothing is known of its structure. At the base of the living chamber there is a groove a millimeter wide, located slightly less than 1 mm. above the uppermost septum. This locates another annular thickening on the interior of the chamber, used for the attachment of the lower part of the animal to the conch.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. The type, represented by figures 3 A, B, on plate LXXIII, is in the Austin collection in the U. S. National Museum. The second specimen, represented by figs. 1 A, B, on plate LXXIV, is in the Welch collection, deposited in Wilmington College.

11. **Orthoceras penicillum** Sp. nov.

Plate LII, fig. 6, plate LXXV, fig. 2

Specimen 85 mm. long, enlarging from a diameter of 6.5 mm. at its base to 9 mm. at a point 78 mm. farther up, or at an apical angle of about 2 degrees. The number of camerae in a length equal to the diameter of the conch most frequently is between 2 and 2.25, but at one point is as low as 1.75, the length of these camerae changing in an irregular manner. At the top of the specimen are 3 camerae shorter than the remainder which may indicate that the conch had reached maturity, but this is not certain since the middle one of this group of 3 is shorter than the one above. The concavity of the septa is less than 1 mm. Nothing is known of the location or structure of the siphuncle.

Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College.

Remarks.—This specimen may belong to the same group as *Orthoceras styloideum* Barrande, from the Middle Silurian of Central Bohemia, now included in Czechoslovakia. In that species, however, the conch is slightly compressed laterally, and the siphuncle is located close to the ventral side of the conch, though not in contact with the latter. Moreover, in that species 3.5 camerae occur in a length equal to the diameter of the conch.

Orthoceras styloideum[1] was selected by Hyatt as a sort of ancestor to *Bactrites*, and the generic term *Protobactrites* was proposed by him for it. However, there is not the slightest trace of a median ventral lobe along the sutures of the septa to support the belief in this ancestry.

12. **Sactoceras** sp. (Cedarville)

Plate LII, fig. 3; plate LXXV, fig. 9

Specimen 95 mm. long, enlarging at an angle of 5 degrees from a diameter of 19 mm. at its base to 28 mm. at its top. The number of camerae in a length equal to the diameter of the conch

[1] *Orthoceras styloideum* Barrande, Systeme Silureien du Centre de la Boheme, vol. 2, text III, 553, pl. 365, figs. 7–11 (1874).

increases from 3.5 along its lower part to 4.5 at its top. In general appearance this specimen resembles the lower part of the phragmacone of *Orthoceras alienum*, as here figured. However, in the Racine species the number of camerae in a length equal to the diameter of the conch decreases with age, while in the Cedarville species it increases with age. The most striking difference, however, is that presented by the siphuncle, whose structure is moniliform instead of cylindrical. Where the diameter of the conch is 20 mm., the passage of the siphuncle through the septum has a diameter of 3.5 mm., increasing to 4 mm. where the diameter of the conch is 24 mm. The septal necks are very short but their lower margins flare widely. Apparently there are obscure traces of the connecting rings, and these traces are interpreted as belonging to moniliform segments of the siphuncle which are 5 mm. in maximum width where the diameter of the conch is 25 mm. Since the connecting rings are not distinctly preserved, the moniliform character of the siphuncle needs confirmation.

Locality and horizon.—Cedarville, Ohio; in the Cedarville dolomite.

GEISONOCERAS Hyatt

The genus *Geisonoceras* was proposed originally for the more broadly banded species, similar to those figured here under the names *Geisonoceras rochesterense* and *Geisonoceras franklinense*. However, in the present paper also the more narrowly banded species are included.

13. Geisonoceras laphami (McChesney)

Orthoceras Laphami McChesney, Desc. New Fossils, p. 91 (1861).
Orthoceras Laphami Meek and Worthen, Geol. Surv. Illinois, 6, p. 504 (1875).

Original description:

Shell elongate, cylindrical, tapering very moderately; septa very convex and distant from a fourth to a third the diameter of the shell. Siphuncle comparatively small, cylindrical or slightly constricted in the septa, subcentral. Surface beautifully marked by revolving striae or lines of growth which pass

around the shell with a slight obliquity to the planes of the septa. This is the most abundant species of this genus in the Niagara limestones of the West, occurring abundantly at Wauwatosa and Milwaukee in Wisconsin, and at Chicago (Bridgeport), and Joliet, Illinois.

In their description of *Orthoceras crebristriatum*, in the publication cited above, Meek and Worthen state that this species "differs from *O. Laphami*, from the same rock, in its much more rapid expansion from the smaller to the larger extremity, and in its compressed instead of cylindrical form, as well as in having the striae passing directly around, instead of obliquely."

The species occurring abundantly at Wauwatosa and Milwaukee, in Wisconsin is *Geisonoceras wauwatosense* (Whitfield), but in the latter the striae are directly transverse. If there is another species of *Geisonoceras* abundant at these localities, it has not come to my attention.

In the list of fossils from the Niagaran formations published by the Geological Survey of Wisconsin, under Chamberlin, *Orthoceras laphami* is listed as occurring at Racine, Greenfield, and Schoonmaker's quarry at Wauwatosa. The Schoonmaker quarry was the source of the type of *Orthoceras wauwatosense*.

14. **Geisonoceras wauwatosense** (Whitfield)

Plate LIII, figs. 2 A-D, 3; plate LVI, fig. 9

Orthoceras Wauwatosense Whitfield, Geol. Wisconsin, 4, 297, pl. 19, fig. 2 (1882).

Original description:

Shell cylindrical, very gradually enlarging from the apex; the increase in diameter being only one-fourth of an inch (6.3 mm.) in a length of three and a half inches (88.9 mm.). Section circular, and the shell quite thick. Septa very deeply concave, in fact but little less than hemispherical. Siphuncle apparently central. Surface of the shell marked by strong, elevated, flattened, encircling lines, which will average about six in the space of one-fourth of an inch (6.3 mm.); but which are not quite regular, sometimes interrupted, and have from one to three finer striae in the spaces between. On one side of the shell the lines make a broad, sweeping curve upwards. There are also fine longitudinal lines at irregular distances and of irregular strength, on some parts being obsolete. The shell has been a very elegant one when perfect, and in its peculiar encircling striae differs from any species known. The specimen, unfortunately, consists of the outer chamber and a single septum only, so that the relative distance of the septa

can not be determined. The striae under a magnifier show considerable variation of form; in some parts being flattened on the surface, in others lightly rounded, and again grooved by deep lines, while the interspaces undergo similar changes; but these variations are too obscure to be apparent to the unaided eye. *Formation and locality:*—In the Niagara group (Racine limestone), at Schoonmaker's quarry, near Wauwatosa, Wisconsin.

Remarks.—The type of this species has been lost, but other specimens from the same locality are not rare. The interior of a living chamber (No. 611) 90 mm. long, is contracted between 5 and 20 mm. from its top for a depth of slightly over half a millimeter around the entire circumference of the chamber. This contraction locates a corresponding thickening of the interior of the shell, no contraction being noticed along the exterior of the latter. Beneath the living chamber of a second specimen (No. 3169a) there are two camerae, of which the upper one is 3 mm., and the lower one is 7 mm. long, their diameter being 30 mm. The sutures of the septa slope rather strongly downward toward one side of the conch, the concavity of the septa becoming slightly greater along the lower part of this slope. The encircling transverse bands or striae on the surface of the conch also slope slightly, but in a direction opposite to the sutures. In a third specimen (No. 3169b), presenting a vertical section of both septa and siphuncle, four and a half camerae occupy a length equal to the diameter of the conch at the top of the series counted. These three specimens are in the Public Museum of Milwaukee, Wisconsin.

In most specimens the concavity of the septa is about one-fourth of the diameter of the conch at the point under investigation. The sutures may be directly transverse, or may slope slightly downward toward one side. The siphuncle is central, and is 6.5 mm. in diameter where the diameter of the conch is 27 mm. The segments of the siphuncle are cylindrical in some specimens; in others they expand slightly between the septa. The shell is very thick, equalling or even slightly exceeding half a millimeter in thickness along the living chamber. The surface of the shell in some specimens is ornamented by narrow transverse bands, flat along their crests, but spreading slightly outward toward their upper margins. In other speci-

mens the crests of these bands are more evenly rounded. In some specimens minute transverse striae appear in addition to the coarser bands, both on the surface of the latter and within the intermediate grooves. In some there are faint vertical raised lines, from a millimeter to a millimeter and a half apart, but much less conspicuous than the transverse striae just mentioned.

On plate LIII four specimens are figured from Wauwatosa, Wisconsin; a fifth is figured on plate LVI. All are numbered 2303 in the Museum of Comparative Zoology at Harvard University.

15. **Geisonoceras crebristriatum** (Meek and Worthen)

Plate LIV, fig. 1

Orthoceras crebristriatum Meek and Worthen, Geol. Surv. Illinois, 6, 503, but not including fig. 2 on plate 26 (1875).

Specimen 305 mm. long. It is estimated that the living chamber occupies 195 mm. of this length. In the figure here presented, the upper half of this chamber, 110 mm. in length, is omitted. Since the margin of the aperture is not preserved, the original length of this living chamber can not be determined. The specimen is strongly flattened, resulting in an elliptical cross-section. The larger diameter enlarges from about 62 mm. at the smaller end of the specimen to 110 mm. at its larger end, or at the rate of nearly 20 mm. in a length of 100 mm. Nothing definite is known as to the number of camerae within a given length of the phragmacone. One septum is located at a point assumed to correspond to the base of the living chamber. Another distinctly defined septum is located 84 mm. farther down. The number of intermediate septa is unknown, but one appears to occur at a point half way between the other two. The location of these three septa is indicated along the left margin of the figure. The septa appear to have been strongly concave. Nothing is known of the siphuncle. The surface of the conch is crossed by transverse striae which vary in number from 12 in a length of 10 mm. at the smaller end of the specimen to 10 in the same length at the larger end.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. Type, numbered 2210 in the Illinois State Museum, at Springfield, Illinois.

Remarks.—Meek and Worthen distinctly state in the publication cited above that the length of the typical specimen is 12.50 inches. This excludes the smaller specimen figured by them as the type of the species. The latter appears to be curved lengthwise along its apical end and may belong to *Elrodoceras*. The conch of the type of *Orthoceras crebristriatum*, however, is straight as far as preserved. The presence of similar transverse striae is not sufficient to establish both specimens as belonging to the same species.

16. **Geisonoceras wortheni** Sp. nov.

Plate LXVI, fig. 2

Cf. *Orthoceras rectum* Worthen, Geol. Surv. Illinois, 6, 504, pl. 26, fig. 3 (1875).

Specimen 224 mm. long; of this length 143 mm. belongs to the living chamber. Apical angle 4 degrees. At the base of the living chamber the larger diameter is 55 mm., the smaller diameter, due to compression after the death of the animal, being about two-thirds as large. The upper three camerae, in descending order, are 9 mm., 13 mm., and 15 mm. in length. The interval between the lowest of these camerae and the base of the specimen is 44 mm. in length and apparently is occupied by two camerae. If that is the case, then the normal number of camerae within a length equal to the diameter of the conch is two and a half. The sutures are directly transverse. The thickness of the shell apparently varies from half a millimeter to almost one millimeter. The surface is ornamented by narrow transverse bands, numbering about 10 to 13 within a length of 10 mm. These bands are flat, but slope slightly outward from their lower toward their upper margin.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. No. 22962, in Walker Museum, Chicago University.

Remarks.—If it were possible in any manner to determine that the type described by Worthen under the name *Orthoceras rectum* was a *Geisonoceras*, the specimen described here would be referred to his species, at least tentatively. However, it is not certain that they belong even to the same genus, hence the specimen here described is designated as new, and is named after A. H. Worthen, who contributed greatly to our knowledge of the paleontology of Illinois.

17. **Geisonoceras rochesterense** Sp. nov.

Plate LIII, fig. 1

Orthoceras imbricatum Hall, Pal. New York, 2, 291, pl. 61, figs. 4a–c; pl. 62, figs. 1–3 (1852). Not *Orthoceras imbricatum* Hisinger.

Conch very strongly flattened, due to pressure after death of the animal; enlarging about 10 mm. in a length of 100 mm. Surface crossed by broad transverse bands, 10 bands occurring in a length equal to the diameter of the conch at the top of the series counted. These bands form an angle of about 7 to 10 degrees with a directly transverse line. At the upper margin of each band there is a sharp edge, above which there is a faint depression. Each band is flat, but slopes slightly outward from its lower toward its upper margin, so that the lower margin of each band appears to invaginate slightly into the upper margin of the band beneath. Nothing is known of the height of the camerae, or of the location, size, or structure of the siphuncle.

Locality and horizon.—Lockport, New York; in the Rochester shale. No. 10401, in the U. S. National Museum.

A similar specimen, No. 18277 in the U. S. National Museum, found on Frost Avenue in Rochester, New York, has a circular cross-section. The specimen enlarges from a diameter of 33 mm. at its base to 39 mm. at its top, the interval being 80 mm., and the rate of enlargement being 7.5 mm. in a length of 100 mm. Ten transverse bands occur in a length of 38 mm., the diameter. The obliquity of these bands, compared with a directly transverse line, equals 10 degrees. The septum at the base of the specimen

has a radius of curvature of about 20 mm. The specimen probably came from some part of the Lockport.

Remarks.—This species differs from *Geisonoceras franklinense* (Miller) in the relatively greater number of its transverse bands, compared with the diameter of the conch.

Orthoceras imbricatum Hisinger, from the Gotlandian of Gotland, is a species of *Armenoceras* with a smooth shell. It is only the sutures of the septa which are oblique. Nothing is known of the generic relationship of *Orthoceras imbricatum* Wahlenberg. The type is lost, but is stated to have had a slender, filiform, central siphuncle. Since the type is lost, and Wahlenberg never figured his species, his claim to the species has been dropped, and Hisinger's name for an altogether different species is widely accepted.

All of the specimens figured by Hall under the name *Orthoceras imbricatum* on his plates 61 and 62, cited above, are numbered 1807 in the American Museum of Natural History. Specimen 4b on plate 61 is from Rochester, New York; the remainder are from Lockport, New York. All are from the Rochester shale.

The specimen represented by Hall on plate 63 of the publication cited above under the name *Orthoceras* —— ?, fig. 5, is a fragment of *Geisonoceras*, showing transverse bands similar to those of *Geisonoceras rochesterense*, but the specimen is figured in an inverted position. It may belong to the latter species, since it is from the Rochester shale at Rochester, New York, but not enough of the conch is included in the fragment to be certain. No. 1812, American Museum of Natural History.

18. **Geisonoceras franklinense** (Miller)

Plate LII, fig. 5 A, B

Orthoceras franklinense Miller, 18th Rep. Dep. Geol. Nat. Res. Indiana, 322, pl. 10, fig. 3 (1894).

Specimen 55 mm. long. 32 mm. in diameter at its top, enlarging at the rate of 10 or 11 mm. in a length of 100 mm.; cross-section circular. The number of camerae within a length equal of the diameter of the conch is unknown. Part of a septum is exposed at the base of the specimen. The suture of this septum

is directly transverse. The concavity of this septum has a radius of curvature of 18 mm. The siphuncle is 4 mm. in diameter, and its center is 10 mm. from the ventral side of the conch, the diameter of the conch at this point being 27 mm. The surface of the shell is crossed by relatively broad bands. Six and a half of these bands occur within a length equal to the diameter of the conch at the top of the series counted. At the top of each band there is an abrupt margin. Immediately above there is a well defined but shallow groove, slightly less than a millimeter in diameter. The bands slope at an angle of 15 degrees beneath a directly transverse line from the dorsal toward the ventral side of the conch.

Locality and horizon.—From some unknown locality in Franklin county, Indiana; in the Laurel limestone member of the Niagaran. No. 64336 in the U. S. National Museum.

Remarks.—Compared with *Geisonoceras rochesterense* Foerste the grooves at the base of each band are much more conspicuous, and the number of these bands within a length equal to the diameter of the conch is less.

ELRODOCERAS Foerste

The genus *Elrodoceras* was founded on *Cyrtoceras indianense* Miller. The species described by Hall under the name *Orthoceras abnorme* has a similar structure. Specimens closely related to *Orthoceras abnorme* are figured here from the Cedarville dolomite of Ohio. Whether the specimens here described as *Elrodoceras cedarvillense* and *Elrodoceras carmani* belong here is not so certain, but this seems the most probable relationship in the present state of our knowledge of these species. The species described by Hall as *Orthoceras crebescens* is not sufficiently well known to determine its relationship with confidence.

19. **Elrodoceras indianense** (Miller)

Plate LIV, fig. 2

Orthoceras crebristriatum Meek and Worthen, Geol. Surv. Illinois, 6, pl. 26, fig. 2, which is not the type of the species (1875).

Cyrtoceras indianense Miller, 17th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 698, pl. 18, figs. 1, 2 (1892).

Elrodoceras indianense Foerste, Jour. Sci. Lab. Denison Univ., 20, 228, pls. 35–38 (1924); 21, pl. 24, fig. 2 (1925).

Conch apparently curved lengthwise along its right outline as here figured. Apparently slightly compressed at right angles to the plane of this supposed lengthwise curvature. At the base of the specimen its maximum and minimum diameters are 32 mm. and 30 mm. respectively, while 25 mm. below its top the corresponding diameters are 47 mm. and 44 mm. Along the right side of the specimen there are traces of directly transverse sutures of septa, from 10 to 12 mm. apart, indicating the presence of 10 camerae within the length of the specimen. At the top, a part of a septum is exposed. This suggests a concavity of 12 or 13 mm. where the diameter of the conch is 45 mm. If the more translucent part at the top of the specimen represents the siphuncle, then the latter attained a diameter of 18 mm., which is large compared with the diameter of the conch. The segments of this siphuncle apparently are similar to those of typical *Elrodoceras indianense*. The transverse striae are nearly straight along two-thirds of the width of the side figured, but curve strongly downward along its left third.

Locality and horizon.—Joliet, Illinois, from the Joliet member of the Niagaran. Figured specimen, numbered 12105 in the Museum of the University of Illinois.

Remarks.—The general aspect of this specimen, and the structure of its interior, as far as known, are similar to *Elrodoceras indianense*. However, in *Elrodoceras indianense* the transverse striae curve downward along the ventral side of the conch, which is convexly curved in a lengthwise direction toward its apical end, while in the Joliet specimen here described the downward curvature is on the side opposite to the supposed convexly curved outline of the conch. This downward curvature is anomalous and can not be explained in the specimen at hand. There is no doubt, however, of the presence of *Elrodoceras indianense* in the Joliet division of the Niagaran. The specimen figured on plate 24 of volume 21 of this Journal came from Joliet, Illinois, and that figured on plate 37 of volume 20 came from a similar horizon at Lemont, Illinois.

20. **Elrodoceras abnorme** (Hall)

Plate LXXII, fig. 1; plate LXXV, fig. 1

Orthoceras abnorme Hall, 20th Rep. New York State Cab. Nat. Hist., 355, pl. 18, fig. 10 (1868).

Type specimen 145 mm. long, with its lower end curved lengthwise, the curvature disappearing farther up. That part of the specimen which is beneath the level of the upper four camerae has a convex ventral outline with a radius of 60 mm., apparently becoming straight along the upper two camerae. The corresponding dorsal vertical outline is straight as far as the conch is preserved, but probably was slightly concave farther down. The lower end of the conch enlarges dorso-ventrally from a diameter of 27 mm. to 40 mm. in a length of 29 mm., and to 54 mm. in an additional length of 40 mm., indicating an apical angle of 27 degrees at the lower end of the specimen, decreasing to 20 degrees farther up. The corresponding diameters of the siphuncle are 14 mm. at the base of the specimen, 20 mm. at a point 29 mm. farther up, with an estimate of 23 mm. at a point 40 mm. farther up, accurate measurement at this upper point being impossible. The structure of the siphuncle appears identical with that of typical *Elrodoceras*. The vertical outlines of the segments of the siphuncle are gently convex. The lower and upper surfaces of these segments are adnate to the intermediate septa along an annular area pierced at the center by the passage of the siphuncle, this passage being considerably smaller in diameter than the diameter of the segments themselves. The interior of the siphuncle is distinctly actinoceroid. At present the endosiphuncular structure consists chiefly of a central strand from which branch more or less horizontal strands at slightly above mid-height of the segments of the siphuncle, as in figures 3B, 4, and 5 on plate LXXII. These deposits are seen best by removing the broken half of the third and fourth camerae from the top of the specimen, which are replaced in fig. 1 of the plate cited. There also are traces of the former calcareous deposits occupying the remainder of the interior of these segments. No trace of the surface of the shell remains so that it can not be deter-

mined if this surface was transversely striated, or banded, or smooth.

Locality and horizon.—Racine, Wisconsin; from the Racine dolomite. Type, numbered 2109, in the American Museum of Natural History.

Remarks.—The affinity of this species to *Elrodoceras* is indicated by its curved apical end and by the structure of its siphuncle. The surface of the shell is not known to be banded transversely, but such a type of ornamentation is to be expected if the reference to *Elrodoceras* is correct.

21. **Elrodoceras** cf. **abnorme** (Hall)

Plate LXXII, figs. 2, 3 A, B, 5

Specimen nearly 100 mm. long, enlarging at an apical angle of 12 degrees, from a diameter of 57 mm. at its base to 75 mm. at a point 85 mm. farther up. Within the limits of the specimen the dorsal side of the conch is almost straight, its ventral outline, on the contrary, is distinctly convex, especially along its lower part which deviates at least 5 mm. from a direct prolongation of the ventral outline along the upper half of the specimen. There is a corresponding change in the direction of the sutures of the septa. These sutures are directly transverse to the curving central axis of the conch. The number of camerae in a length equal to the diameter of the conch at the top of the series counted is 5. The siphuncle is exposed at the base of the specimen and its location appears to be slightly dorsad of the center. The vertical outlines of these segments are strongly convex, as in the type of *Elrodoceras abnorme*. Their maximum diameter can not be determined with accuracy, but it appears to be about 20 mm. where the diameter of the conch is 57 mm. The central strand of the endosiphuncle and a trace of some of its lateral branches is retained. The character of the ornamentation of the shell can not be determined.

Locality and horizon.—Cedarville, Ohio; in the Cedarville dolomite.

Remarks.—While this specimen is regarded as closely related

to *Elrodoceras abnorme*, and has a similar vertical outline along the segments of its siphuncle, it is not known to belong to the same species. At least, the number of camerae in a length equal to the diameter of the conch is greater than along the upper part of the type of *Elrodoceras abnorme*.

The fragments of the siphuncles illustrated by figures 3 A, B and 5 on plate LXXII, may belong to the same species as the specimen here described. The first of these was found at Cedarville; the second was found in the quarries southwest of Springfield; both in the Cedarville dolomite.

22. **Elrodoceras cedarvillense** sp. nov.

Plate LXXIV, fig. 3

Specimen 108 mm. long, enlarging at an apical angle of 10 degrees, from a diameter of 50 mm. at its base to 63 mm. at a point 75 mm. farther up. No lengthwise curvature of the conch is noted within this length. The sutures of the septa are directly transverse. The number of camerae within a length equal to the diameter of the conch at the top of the series counted is 6. The concavity of the septa equals 17 mm. where the diameter of the conch is 60 mm. The location of the siphuncle at this point is central and its diameter is approximately somewhere between 10 mm. and 12 mm. Only traces of this siphuncle are exposed, but its segments appear to have had vertical outlines somewhat similar to those in figures 4 and 5 on plate LXXII. Within the sixth and seventh camerae above the base of the specimen, sufficient of the structure of the interior of the segments of the siphuncle is preserved to indicate that it was filled by typically actinoceroid deposits. Along the eighth and ninth camerae a small part of the shell is preserved, showing that the exterior of this shell was striated transversely, 22 striae occurring in a length of 20 mm. These striae belong to the banded variety, the surface of the individual bands being flat, but sloping outward from their lower toward their upper margin, so that successive bands appear to invaginate into each other.

Locality and horizon.—Cedarville, Ohio; in the Cedarville dolomite.

Remarks.—This specimen is characterized by its relatively numerous camerae within a length equal to the diameter of the conch. While the vertical outline of the segments of its siphuncle appears similar to that of the siphuncle represented in figure 4 on plate LXXII, it is not known to belong to the same species. The latter, however, is evidently a characteristic siphuncle of some species of *Elrodoceras*, and was found at Cedarville, Ohio, in the Cedarville dolomite.

23. **Elrodoceras** sp. (Wilmington)

Plate LXXIII, figs. 2, 1

Conch enlarging at an apical angle of 10 degrees, from a diameter of 51 mm. at its base to 71 mm. at a point 110 mm. farther up. The number of camerae in a length equal to the diameter of the conch varies from 4 along the lower part of the specimen to 3.3 along its upper part. The location of the siphuncle is subcentral. Two segments are exposed, that within the camera at the base of the specimen and that within the fifth camera from the base. These show the characteristic deposits found in the interior of the siphuncle of the type of *Elrodoceras abnorme* and also in the segments of the siphuncle represented by figure 5 on plate LXXII. The lowest camera also shows the pseudo-cystoid structure often found in the camerae of certain actinoceroids.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection deposited in Wilmington College.

The specimen represented by figure 1, on the same plate as the preceding specimen, was found at Cedarville, Ohio, in the same horizon. It has the same apical angle, and may possibly belong to the same species, but the structure of its siphuncle is not known.

24. **Elrodoceras** (?) **carmani** Sp. nov.

Plate LXXI, fig. 1

Specimen 145 mm. long, enlarging at an apical angle of about 5 degrees, from a diameter of 75 mm. at its base to 90 mm. at a

point 125 mm. farther up. The number of camerae within a length equal to the diameter of the conch at the top of the series counted is 6. The concavity of the septa is 30 mm. where the diameter of the conch is 88 mm. The location of the siphuncle is slightly over one-third of the diameter of the conch from the ventral side. The passage of the siphuncle through the septum is 8 mm. in diameter at the top of the specimen. At this point the segment of the siphuncle in contact with the septum beneath forms a contact surface of 13 mm., the segment itself enlarging to 15 mm. at mid-height of the camera. In general appearance the vertical outline of the segments of the siphuncle resembles that of *Elrodoceras indianense*, but it is not known that the structure at the septal neck is the same. In the species cited the septum is in contact not only with the base of the overlying segment of the siphuncle for a considerable width, but also with the top of the underlying segment for the same width. This appears to be the structure also of the specimen here described, but the state of preservation of the specimen is not sufficiently good to make this certain.

Locality and horizon.—From Greene county, Ohio; in the Cedarville dolomite; apparently from the quarry at Cedarville. No. 1876, in the museum of Ohio State University. Named in honor of Prof. J. E. Carman of Ohio State University.

25. **Elrodoceras** (?) **crebescens** (Hall)

Plate XLVIII, fig. 1, plate XLIX, fig. 2; plate LXXV, fig. 7

Orthoceras crebescens Hall, 20th Rep. New York State Cab. Nat. Hist., 354, pl. 19, figs. 1–3.

Type specimen 160 mm. long, enlarging at an apical angle of 10 degrees from a diameter of 57 mm. at its base to 74 mm. at a point 90 mm. farther up. At a point 60 mm. above the base of the living chamber the cast of the interior of the conch ceases to enlarge, but apparently becomes cylindrical for a length of 30 mm., judging from the fact that along this part of the chamber the vertical outline of the cast bends inward 2 mm. in a length of 30 mm. from a direct continuation of the vertical outline of the remainder of the specimen. Of the living chamber a length of 90

mm. is preserved. Between 2 and 3 mm. above the suture at the base of the cast of this chamber there is a narrow groove, evidently corresponding to an annular thickening of the inner wall of the shell, used as an attachment ring by the basal part of the animal. The four camerae along the lower part of the specimen indicate the presence of 5.5 camerae within a length equal to the diameter of the conch at the top of the series counted. The sutures of the septa are directly transverse. Where the diameter of the conch is 57 mm., the concavity of the septum is 18 mm., and the center of the siphuncle is located 27 mm. from the nearest side of the conch. At this point, the passage of the siphuncle through the septum is 5 mm. in diameter, and the immediately overlying segment of the siphuncle is in direct contact with the upper surface of this segment for a diameter of 8 mm. at least. The segments themselves are not preserved, so that their structure can not be determined from this specimen. The shortening of the upper three camerae indicates that the conch had entered on its gerontic stage. No part of the shell is preserved, but along one side of the living chamber there appears to be a transference of the surface ornamentation to the cast of the interior of the chamber, sufficient to suggest that it was transverse, and possibly of the banded character. There is not the slightest trace of even the faintest vertical ribbing. Plate XLVIII, fig. 1.

The second specimen figured by Hall is 136 mm. long. It enlarges at a diameter of 12 degrees, the diameter at the second suture beneath the top of the specimen being 65 mm. There are 4.75 camerae in a length equal to the diameter of the conch at the top of the series counted. The segments of the siphuncle are exposed along the lower 3 camerae. Here they are 14 mm. in diameter at mid-height, and the passage through one of the septa narrows to a diameter of 7 mm. The structure of the siphuncle at the septa is not clearly exposed but it appears to be that of *Elrodoceras*, the segments above and below the septa being in contact with the latter for a width of at least 1.5 mm. around the opening through the septa, the vertical outline of the lateral walls of these segments being convex. Within the seg-

ments of the siphuncle there are poor traces of actinoceroid structure. Traces of the shell adhere to various parts of the specimen. The surface of these traces of shell appears to be nearly smooth. There are no indications of vertical ribbing, nor any satisfactory traces of transverse striae or bands, but there is a possibility that only the inner layers of the shell are preserved and that its exterior surface may have had markings of some kind, possibly transverse.

The third specimen figured by Hall is a phragmacone preserving 10 camerae in a length of 118 mm. The apical angle of this specimen is similar to that of the type. The diameter at its top is estimated at 63 mm. The number of camerae in a length equal to the diameter of the conch at the top of the series counted is 5 at the lower end of the specimen, diminishing to 4.5 at its top. At the base of the specimen, where its diameter is 39 mm., the concavity of the septum has a depth of 8 mm.; the passage of the siphuncle through the septum here is 10 mm. in diameter; and this passage is surrounded by an annular area 1 mm. in width and 12 mm. in diameter, along which the segments of the siphuncle are in contact with the septum between. Originally this passage through the septum may have been smaller, as in the type specimen. The segment of the siphuncle exposed at the base of the specimen evidently enlarged within the camera, and its interior suggests actinoceroid structure. This specimen is a cast of the interior of a conch, and its surface shows traces of broad transverse markings which possibly might be connected with transverse banding on the exterior surface of the shell. There are also faint vertical markings, almost too vague to be seen even under transverse illumination. About 7 of these vertical markings occur in a width of 20 mm. where the lateral diameter of the conch is 47 mm. There is no evidence that these vertical markings have any connection with any vertical striae on the exterior of the shell, similar to those of *Protokionoceras medullare* (Hall).

Locality and horizon.—Racine, Wisconsin; in the Racine dolomite. No. 2107, American Museum of Natural History.

Remarks.—As far as can be determined from the three speci-

mens figured by Hall, the structure of the siphuncle of *Orthoceras crebescens* is that of an actinoceroid similar to that of *Elrodoceras*. It differs from *Ormoceras* in the absence of septal necks and in the resulting absence of a gap between septa and the top of each of the immediately underlying segments of the siphuncle. The first specimen figured by Hall favors the presence of transverse striae or bands. The second specimen appears to have been smooth, and the third may have been transversely banded, but the evidence is not clear. The extremely vague vertical markings on the cast of the interior of the conch in the third specimen does not necessarily imply the presence of vertical markings on the surface of the shell, and the general actinoceroid structure of the siphuncle is entirely opposed to any association of this species with any form of *Kionoceras* or *Protokionoceras*. Its reference to *Elrodoceras* therefore is provisional, but is regarded as more likely than that to *Protokionoceras*.

CYCLOCERAS M'Coy

The term *Cycloceras* as employed by M'Coy included all annulated orthoconic cephalopods. It therefore included not only the species at present referred to that genus, but also those now referred to *Spyroceras* and *Dawsonoceras*. At present the tendency is to limit the name *Cycloceras* to those annulated forms in which only straight transverse striae occur in addition to the annulations, the transverse striae of *Dawsonoceras* being undulating, and the transverse striae of *Spyroceras* being supplemented or altogether replaced by vertical striae. In typical species of *Cycloceras* the annulations and transverse striae are distinct.

Among the species here referred to *Cycloceras*, not one has strongly developed annulations, and not one is known to have transverse striae. The absence of transverse striae is not known to have any significance, since none of the specimens studied preserves the shell, and the surface of the latter remains unknown, but it is of some significance that in all of these species the annulations are relatively low, and, in some cases, even faint.

There are two groups among these species. One is typified by

Cycloceras niagarense (Hall), and includes also *Cycloceras brucense* (Williams), and *Cycloceras jolietense*. In this group the conch enlarges at a distinct though moderate rate, and the camerae are relatively short. In the second group, typified by *Cycloceras semotior*, the rate of enlargement is relatively small, and the camerae are relatively much longer. This group includes also *Cycloceras austini*, possibly also *Cycloceras junciforme*. For the third group, the name *Leurocycloceras* is proposed on a later page of this paper. This is typified by *Leurocycloceras raymondi* Foerste, a species in which the surface of the shell is conspicuously annulated, but there are no transverse striae. It is evident that much more information is needed before the relationship of these species can be regarded as fully determined.

26. **Cycloceras niagarense** (Hall)

Plate LV, fig. 2; plate LVII, fig. 1; plate LXXV, fig. 10

Orthoceras niagarense Hall, 20th Rep. New York State Cab. Nat. Hist., 356, pl. 26, fig. 3 (1868).

Conch enlarging at an apical angle of 5 degrees, compressed laterally after death of the animal. The number of camerae in a length equal to the diameter of the conch is 4. Septa deeply concave. Siphuncle not exposed. The number of annulations in a length equal to the diameter of the conch enlarges from 9 at the lower end of the specimen to 12 at its top. These annulations remain of about the same width while the diameter of the conch increases. They are low, broad, but distinct. The sutures slope at an angle of about 5 degrees, but the sutures of the septa slope at an angle 5 degrees greater and in the same direction. There is no trace of the shell, and no trace of transverse striae parallel to the annulations.

Locality and horizon.—Waukesha, Wisconsin; in the Waukesha dolomite, the formation directly beneath the Racine. Type, No. 2152, American Museum of Natural History.

Bridgeport specimen.—Specimen 150 mm. long, enlarging at an angle of 6 degrees. The number of camerae in a length equal to the diameter of the conch varies from two and one-fifth to two and a third along the lower three-fourths of the specimen

but increases to three at its top. The sutures of the septa slope at an angle of 6 degrees with the horizontal, and the slope of the annulations on the surface of the shell is about 4 degrees greater. The number of annulations in a length equal to the diameter of the conch at the top of the series counted increases from 9 to 10 along the upper half of the specimen. The height of these annulations is about a fourth of a millimeter. The concavity of the septa equals 8 mm. at the top of the specimen, where its diameter is 33 mm. The siphuncle is located slightly more than a third of the diameter of the conch from its ventral side. The diameter of the siphuncle is 3 mm. where that of the conch is 26 mm. Its form is nearly cylindrical.

Locality and horizon.—Bridgeport (Chicago), Illinois; from the Racine dolomite. No. 7762 in the Illinois State Museum of Natural History, at Springfield, Illinois.

Remarks.—On first appearance, the two specimens here described appear very distinct. However, there is considerable similarity in the relative slope of the sutures of the septa and of the annulations. Moreover, these annulations are of about the same size. Further, there is only a moderate decrease in the length of the camerae from the lower part of the smaller specimen to the top of the larger one, so that there is a possibility of these two specimens belonging to the same species.

27. **Cycloceras brucense** (Williams)

Plate LIV, fig. 3; plate LVII, fig. 5

Orthoceras brucensis Williams, Geol. Survey Canada, Mem. 111, 124, pl. 26, figs. 1, 2; pl. 27, fig. 1.

Conch with an apical angle of 5 degrees, enlarging about 9 mm. in a length of 100 mm. About two and a half camerae occupy a length equal to the diameter of the conch at the top of the series counted. Sutures directly transverse. Septa with a concavity of 5 mm. where the diameter of the conch is 17 mm. Siphuncle excentric, its center being 6 mm. from the ventral wall where the diameter of the conch is 11.5 mm. Septal necks 2 mm. wide and 1.5 mm. long extending almost directly downward, but no siphuncular tube connecting successive segments of the siphuncle can be detected.

Locality and horizon.—Hay Bay, Bruce peninsula, Ontario. No. 5732, Geol. Surv. Canada. In the Guelph formation.

The annulated specimen figured by Williams on plate 27, cited above, is here refigured. It enlarges at an apical angle of 5 degrees. It attains a diameter of 27 mm., and at this point 2.6 camerae occur in a length equal to the diameter of the conch. The sutures of its septa are directly transverse, and the transverse annulations form an angle of 16 degrees with the latter. Ten annulations occur in a length equal to the diameter of the conch. The annulations are low and broad. Pine Tree harbor, Bruce peninsula, Ontario. No. 5135, Geol. Surv. Canada.

Remarks.—The annulated specimen is closely related to *Cycloceras niagarense* Hall, from which it differs in the smaller number of camerae in a length equal to the diameter of the conch, and in the greater obliquity of its annulations.

It is not known that the type of *Orthoceras brucensis* is annulated and there is a possibility that the annulated specimen belongs to a distinct species.

28. **Cycloceras jolietense** Sp. nov.

Plate LV, fig. 1

Specimen 180 mm. long, enlarging from a diameter of 26 mm. at its base to 48 mm. at the base of the living chamber which is 166 mm. farther up; the apical angle is 8 degrees. The number of camerae in a length equal to the diameter of the conch varies from 2.5 or 2.7 along the lower part of the specimen to 3 near its top. The upper 2 camerae are distinctly shorter than those immediately beneath, indicating that the animal was mature. The surface of the cast of the conch is weakly annulated. Along the lower half of the specimen these annulations are fairly distinct, and number about 11 in a length equal to the diameter of the conch at the top of the series counted. Along the upper half of the specimens these annulations are only very faint, but are equally numerous compared with the diameter of the conch. These annulations slope gently downward at an angle of 5 degrees. The sutures of the septa, however, slope still more gently downward, at approximately an angle of 2 or 3 degrees with the hori-

zontal, and in a direction opposite to the slope of the annulations. This difference in the direction of the slope probably has no diagnostic value. No traces of surface striae is preserved.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. No. 22963, Walker Museum, Chicago University.

Remarks.—*Cycloceras jolietense* differs from *Cycloceras niagarense* (Hall), from the Waukesha member of the Niagaran at Waukesha and Pewaukee, Wisconsin, in its larger apical angle and in the somewhat smaller number of its camerae in a length equal to the diameter of the conch.

29. **Cycloceras austini** Sp. nov.

Plate LVI, fig. 1; plate LXXV, fig. 6

Conch enlarging very slowly, from 23 mm. to 27 mm. in a length of 175 mm. The length of the camerae equals their diameter in most cases, but in a few cases is slightly shorter. The sutures of the septa are directly transverse. The septa are deeply concave, their radius of curvature being 13 mm. The location of the siphuncle is slightly excentric. Its diameter is 3 mm. where the diameter of the conch is 24 mm. Apparently the siphuncle contracts slightly at its passage through the siphuncle, but its general form is cylindrical. Very faint annular undulations cross the cast of the interior of the conch. These are readily visible only under cross-illumination; 13 occur in a length of 40 mm. at the smaller end of the specimen. They cross the plane of the septa at a slightly oblique angle. If the side toward which these annulations slope is regarded as the center, then the siphuncle is located slightly dorsad of the center of the conch. This is not known to have any diagnostic value.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Named in honor of Dr. George M. Austin.

30. **Cycloceras semotior** Sp. nov.

Plate LVII, fig. 3; plate LVI, figs. 2A, B

Specimen consisting of the lower part of a living chamber and of at least 5 camerae. There may be a sixth camera at the top

of this series, but the septum at the top of this sixth camera is indistinctly defined. The entire length of this specimen is 205 mm., and of this length 123 mm. belongs to the 6 camerae. Only the basal part of the living chamber is preserved. Most of the camerae are from one and a fourth to one and a third times as long as the diameter of the conch, but some are of the same length, and a few are shorter. The chief difference between this species and *Cycloceras austini* is the smaller number of annulations within a length equal to the diameter of the conch. Of these 14.5 occur in a length of 50 mm. These annulations are low and broad. Nothing is known of the character of the surface of the shell. The specimen enlarges from 18 mm. at its base to 23 mm. at its top. The septa are deeply concave. Nothing is known about the siphuncle.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. The specimen described above is numbered 2209 in the Illinois State Museum of Natural History, at Springfield, Illinois. A second specimen, figured on plate LVI, is numbered 22961 in the museum of the University of Chicago.

31. **Cycloceras junciforme** Sp. nov.

Plate LVI, figs. 3, 4

Specimen slender, enlarging only 1 mm. in diameter in a length of 70 mm. Cross-section circular. Living chamber 103 mm. long. Between 55 and 75 mm. above its base the inner surface of the shell was thickened so that a cast of the interior of this chamber appears constricted, the maximum constriction equalling about 1 mm. The sutures of the septa are directly transverse. If the two lower camerae are of normal size for the main body of the conch then 3 camerae occur in a length equal to the diameter of the conch. The overlying camerae are distinctly shorter, indicating that the animal was entering on its gerontic stage. Nothing is known of the siphuncle. The upper half of the living chamber is faintly annulated, the annulation being visible only on cross-illumination. The crests of 5 annulations occur in a length of 11 mm. No annulations can be detected along the lower half of the specimen.

In a second specimen, assumed to be a fragment of the living chamber, the annulations are much more distinct, though still low, scarcely a sixth of a millimeter in height. There are about 11 annulations in a length of 30 mm. These annulations are oblique along the lower part of the specimen and nearly directly transverse farther up.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. In the collection of Dr. George M. Austin, in the U. S. National Museum.

32. **Cycloceras** sp. (Port Byron)

Plate LVII, figs. 6, 2, 7

Specimen enlarging at an apical angle of nearly 3 degrees and attaining a diameter of 16 mm. at the base of the living chamber. Of this chamber a length of 65 mm. is preserved. At its base is a single camera whose length is almost equal to its width. Only the cast of the conch is present, and this is smooth, the transverse annulations being nearly obsolete.

In a second specimen, consisting of a single camera and half of the overlying camera, the surface also is smooth. Both the length and the diameter of the complete camera are 14 mm.

The third specimen consists of a single camera with part of the camera beneath and less of the camera above. Both the length and the diameter of this fragment are 15 mm. Nearly 6 annulations occur within this length. The annulations slope at an angle of 5 degrees compared with the sutures of the septa.

Locality and horizon.—Port Byron, Illinois; in the Port Byron member of the Niagaran. Nos. 444, 445, and 442, in the Ward collection belonging to the U. S. National Museum.

Remarks.—The longer specimen, represented by figure 6, has a distinctly larger apical angle than typical specimens of *Cycloceras austini* and *Cycloceras semotior*. The other two specimens are too short to permit the determination of their apical angle. However, they are assumed to belong to the same species, and all three are referred to *Cycloceras*.

LEUROCYCLOCERAS Gen. nov.

Genotype: *Leurocycloceras raymondi* Foerste.

Orthoceroids having surface of shell annulated as in *Cycloceras*, but not striated transversely as in *Cycloceras*, nor vertically as in *Spyroceras*.

33. **Leurocycloceras raymondi** Sp. nov.

Plate LVII, figs. 4 A-C. plate LVI, figs. 5 A, B

Specimen consisting of a living chamber 60 mm. long, enlarging from a lateral diameter of 18 mm. at its base to 19 mm. at its top, the corresponding dorso-ventral diameters being 17.5 mm. and 18 mm. The suture of the septum at its base is directly transverse, and the concavity of this septum is 3.5 mm. The surface of the shell is obliquely annulated, there being 8 annulations in a length equal to the lateral diameter of the conch. These annulations rise moderately along the middle of the lateral sides; thence they rise more strongly in a dorsad direction and slope still more strongly downward in a ventrad direction. The dorsal crests outlined by these annulations are broadly convex. The ventral sinuses are distinctly narrower and more angular. The annulations are prominent laterally, but tend to become fainter along the median part of the dorsal and ventral sides. In the specimen at hand they become entirely obsolete along the median part of the dorsal side, and apparently also along the corresponding part of the ventral side. The shell is 1 mm. thick at the crest of the annulations, and half as thick at the deeper part of the intermediate grooves. Plate LVII, figs. 4 A-C.

Locality and horizon.—Wauwatosa, Wisconsin; in the Racine member of the Niagaran. No. 428 in the Ward collection in the U. S. National Museum. Similar specimens occur in the Teller collection in the same museum. Named in honor of Prof. Percy E. Raymond, of Harvard University.

A similar specimen, 35 mm. long, 14 mm. in diameter laterally, and 12.5 mm. dorso-ventrally, was found in Busack's quarry, which was formerly the extreme western quarry at Wauwatosa, Wisconsin. It has 9 oblique annulations in a length equal to

its lateral diameter. They slope in a ventrad direction at an angle of 10 degrees with the horizontal. Along the median part of the ventral and dorsal sides they tend to become obsolete. This specimen is more prominently annulated than the preceding, but is regarded as merely a younger specimen. No. 2306a in the Museum of Comparative Zoology, Harvard University. Plate LVI, figs. 5 A, B.

This probably is the species listed by the Geological Survey of Wisconsin, under Chamberlin, from the Niagaran of the Schoonmaker quarry west of Wauwatosa, Wisconsin, under *Orthoceras trochleare.*

34. **Leurocycloceras wisconsinense** Sp. nov.

Plate LVI, figs. 6, 7

Specimen 57 mm. long, apparently a living chamber retaining the septum at its base. This chamber is crossed by directly transverse annulations, weakly defined, and numbering 7 in a length equal to the diameter of the conch.

The second specimen here figured is 41 mm. long, and evidently belongs to the upper part of a living chamber, and includes the constricted part characteristic of the upper part of the living chamber of many conchs, at least during their gerontic stages. The annulations are directly transverse, and number 7.5 in a length equal to the diameter of the conch.

Locality and horizon.—Busack quarry, Wauwatosa, Wisconsin. No. 2306 c, b, in the Museum of Comparative Zoology, Harvard University.

35. **Dawsonoceras hyatti** Foerste

Plate XLVIII, figs. 2 A, B; plate LVIII, figs. 4, 1, 2, 5; plate LIX, fig. 2; plate LXXV, fig. 3

Dawsonoceras hyatti Foerste, Jour. Sci. Lab. Denison Univ., 23, p. 28, pl. 4, fig. 2; pl. 28, fig. 6 (1928).

Living chamber 76 mm. long, depressed dorso-ventrally. At the base of the chamber the lateral diameter is 45 mm. and the dorso-ventral one is 40 mm. at the transverse annulations.

These diameters enlarge to 48 mm. and 41 mm. respectively at the annulation 40 mm. farther up, and then diminish to 44 mm. and 37.5 mm. respectively two annulations still farther up, enlarging again distinctly at the next annulation. These measurements, taken along the cast of the interior of a living chamber, suggest that the constriction along the upper part of the chamber corresponds to similar constrictions along the upper part of living chambers in other orthoceroids, and locates a corresponding annular thickening on the interior of the shell along the upper part of the chamber. In this constriction the annulations of the shell are less conspicuous. About 6 annulations occur in a length equal to the lateral diameter of the conch. On one of the broader sides, assumed to be the ventral one, the annulations curve slightly downward. On cross-illumination, a few faint elevations are observed along the crest of the annulations, at intervals suggesting the presence of about 15 elevations within the circumference of the conch. These nodose elevations are arranged in vertical series and are connected by still fainter vertical ridges.

In a second specimen the lateral apical angle is 4.5 degrees. The sutures of the septa occupy the grooves between the annulations for a length of 3 camerae. Neither of these 2 specimens preserves a trace of the surface ornamentation.

Locality and horizon.—Port Byron, Illinois; in the Port Byron member of the Niagaran. In the collection of Prof. T. E. Savage. Plate XLVIII, figs. 2 A, B.

Remarks.—Although these specimens are referred to *Dawsonoceras hyatti*, the faint vertical markings are suggestive of the much more prominent vertical ridges in *Dawsonoceras nodocostatum* McChesney.

Springfield specimen.—Specimen about 75 mm. long. Lateral diameter enlarging from 41 mm. to 50 mm. in a length of 50 mm. The number of annulations in a length equal to this diameter equals six and a half. Surface of the shell ornamented with undulating transverse striae of which 3 or 4 occupy the grooves between the annulations. These undulations are broader and less numerous than in typical *Dawsonoceras hyatti*. From the

quarries southwest of Springfield, Ohio; in the Cedarville dolomite. In the museum of Wittenberg College. Plate LVIII, fig. 4.

Joliet specimen.—Specimen 210 mm. long, enlarging from a diameter of 42 mm. at its base to 47 mm. at its top. Only a part of this specimen is figured here. Apparently depressed dorso-ventrally. On the figured side, regarded as ventral, the annulations curve distinctly downward near mid-height of the specimen, but only slightly downward at its upper and lower ends. On the opposite side of the conch, assumed to be dorsal, the annulations are directly transverse. The shell is greatly thickened at the annulations, the latter rising about 2 mm. above the intermediate grooves on the actual shell, but rising only 1 mm. at the annulations on the cast of the interior of the conch. The transverse undulating striae tend to be more crowded on the annulations than in the intermediate grooves. Where these striae curve upward, low broad and not very distinct vertical ribs tend to form as in *Dawsonoceras multiliratum* Foerste. Of the annulations, 6.5 occur in a length equal to the diameter of the conch. Of the vertical ribs, 9.5 occur in a width of 10 mm. near mid-height of the specimen. Usually only 3 or 4 transverse striae occur within the transverse grooves, while 6 to 8 may occur on the much narrower annulations. Sutures of the septa are exposed along the lower half of the specimen. These number about as many as the annulations, although there is no strict agreement in their number when considerable lengths of the same conch are studied. Joliet, Illinois; in the Joliet member of the Niagaran. No. 15001, Walker Museum, Chicago University. Plate LIX, fig. 2.

Wilmington specimens.—Conch slowly enlarging, at a lateral apical angle of 3 degrees; usually depressed dorso-ventrally, the ratio of the dorso-ventral to the lateral diameter being as 5 to 6. The sutures of the septa usually occupy the grooves between the annulations. The siphuncle is central in location, and its diameter equals about two-elevenths of the lateral diameter of the conch. The annulations usually are nearly directly transverse, except on the ventral side of the conch, where they frequently curve distinctly downward. On conchs 50 mm. in diam-

eter, the annulations often reach an elevation of 2 mm. above the intermediate grooves. The shell of the conch is distinctly thicker along the annulations. Usually about 3 transverse striae occur in each groove between the annulations. These striae are undulated. In one specimen, 52 mm. wide, there are 5 upward curvatures to these annulations along a width of 10 mm. where these undulations are best preserved. From the Moodie quarry in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Plate LVIII, figs. 1, 2.

A vertical section through part of a conch found at Cedarville, Ohio, is represented by figure 5, on plate LVIII.

36. **Dawsonoceras nodocostatum** (McChesney)

Plate LVIII, fig. 3; plate LIX, fig. 1

Orthoceras nodocostum McChesney, Descr. New Fossils, 94 (1861).
Orthoceras nodicostatum McChesney, Trans. Chicago Acad. Sci., 1, 53, pl. 9, fig. 5 (1869).

Original description:

> The surface characters of this species are all that the condition of the specimens exhibits; but these are so distinct and characteristic that the species is sufficiently separated from any known species by them. The surface is marked by annulations somewhat similar to those of *O. annulatum*, but they are more angular and the spaces between them more regularly concave, and marked by indistinct concentric striae. The annulations are crossed by low, equidistant longitudinal lines or ridges, which are distant a little more than half the distance of the annulations from each other, and at their crossings the matrix of the shell is punctured as if by sharp nodes or low spines. *Geological position and locality.* In Niagara limestone, Milwaukee, Wisconsin.

Springfield specimen.—Specimen 90 mm. long, enlarging from a diameter of 24 mm. at its base to 30 mm. at its top, the interval being 78 mm. measured from crest to crest of the annulations. The number of annulations in a length equal to the diameter of the conch is slightly over 5. In addition to these annulations there are fine transverse striae of which 6 occur in a length of 3 mm. The vertical ribs are alternately stronger and fainter, the number of stronger ribs being estimated at 20 within the circumference of the conch. Where the diameter of the conch is 28 mm., the stronger ribs are between 4 and 5 mm. apart, the inter-

mediate ribs being much fainter. The width of the stronger ribs equals scarcely one millimeter. The transverse striae curve slightly upward on crossing the ribs, and downward within the grooves between the ribs. From the quarries southwest of Springfield, Ohio; in the Cedarville dolomite. In the Museum at Wittenberg College.

Small specimens, from 16 to 26 mm. in diameter, occur at the same horizon in the Moodie quarry, in the southeastern part of Wilmington, Ohio. On these specimens about 16 of the more prominent vertical ribs occur within the circumference of the conch.

Grafton specimens.—Conchs fairly large, one specimen attaining a diameter of 60 mm. Their rate of enlargement equals 8 mm. in a length of 100 mm. One living chamber, between 40 mm. and 45 mm. in diameter at the base, is at least 160 mm. long. The sutures of the septa usually occupy the grooves between the annulations. The radius of curvature of the septa is 25 mm. in a specimen 45 mm. in diameter. The surface of the conch is strongly annulated, 5 or 6 annulations occurring in a length equal to the diameter of the conch. In a specimen 50 mm. in diameter, the annulations are 3.5 mm. wide, the width of the intermediate grooves being 7 mm. The annulations rise from 2.7 to 3 mm. above the intermediate grooves. The surface of the shell in marked by 19 or 20 primary ribs, and by an equal number of less prominent secondary ribs. In some specimens there may be even a tertiary series, 38 or 40 in number, and very faint in definition. Where the primary ribs cross the annulations they are more distinctly elevated than in the intermediate grooves thus producing the appearance of nodes on the annulations, these nodes being vertically elongated however. The secondary ribs sometimes are relatively inconspicuous on the annulations, and the tertiary ribs usually are not noticed. Finally, the entire surface of the shell is crossed by transverse striae, parallel to the annulations. These striae occur at the rate of 5 to 7 in a length of 5 mm. within the grooves between the annulations, while 5 frequently occur in a length of only 2 mm. on the crest of these annulations. Where the transverse striae cross the vertical ribs

they curve more or less strongly upward, leaving concave scallops on the intermediate areas. Grafton, Illinois, in the Racine member of the Niagaran. In the U. S. National Museum.

A specimen somewhat intermediate between typical *Dawsonoceras nodocostatum* and *Dawsonoceras granti* Foerste is represented by figure 1 on plate LIX of this bulletin. From the Racine dolomite. In the U. S. National Museum.

37. **Dawsonoceras graftonense** Sp. nov.

Plate LVIII, fig. 6

Specimen 72 mm. long, enlarging from a lateral diameter of 14 mm. at its base to 20 mm. at its top, the corresponding dorso-ventral diameters being 13 and 18 mm. The annulations are low and broad; in fact, they appear broader than the intermediate grooves. At the top of the specimen the annulations rise only three-fourths of a millimeter above the intermediate grooves. The transverse undulating striae are relatively distant and remarkably equal in their spacing, 8 occurring in a length of 10 mm. at the top of the specimen. Along the median part of the ventral side these striae curve slightly, but distinctly downward. Along the dorsal side of the conch these striae are nearly directly transverse. From 5 to 6 of the downward curving scallops of the transverse striae occur in a width of 5 mm. The siphuncle is exposed at the top of the specimen. Its location is central and its diameter is 4 mm.

Locality and horizon.—Grafton, Illinois; in the Racine member of the Niagaran. No. 23107, Walker Museum, Chicago University.

38. **Dawsonoceras bridgeportense** Sp. nov.

Plate LXI, figs. 2, 1

Specimen 120 mm. long, enlarging in a dorso-ventral direction from 16 mm. at its base to 21 mm. at its top, the apical angle equalling nearly 3 degrees. Sharply annulated. About 5 annulations occur in a length equalling the dorso-ventral diameter of the conch along the lower part of the specimen, increasing to

5.5 annulations along its upper part. Along that part of the conch regarded as dorsal these annulations are directly transverse, but along the middle of the ventral side they are strongly deflected downward. Along the median part of both the dorsal and ventral sides the annulations are much weaker than laterally. Along the ventral side of the conch the transverse undulating striae number 9 in a length of 5 mm. In addition there are low vertical ribs or striae, most distinct ventro-laterally, numbering about 9 in a width of 10 mm. (fig. 2).

In a second specimen, about 95 mm. long, the lateral apical angle is nearly 5 degrees. Only the dorsal and lateral sides are exposed, and the annulations here are directly transverse. These annulations vary in number from 5 in a length equal to the diameter of the conch along its lower part to 6 in a corresponding length toward its top. The vertical ribs or striae number 6.5 in a width of 10 mm. (fig. 1).

Locality and horizon.—Bridgeport (Chicago), Illinois; in the Racine member of the Niagaran. Nos. 23103, 23104, Walker Museum, Chicago University.

39. **Dawsonoceras americanum** (Foord)

Plate LXI, fig. 5

Dawsonoceras americanum Foerste, Jour. Sci. Lab. Denison Univ., 23, 34, pl. V, figs. 2, 3, 4; plate IX, fig. 3; plate 28, figs. 4 A, B (1928).

An additional figure of this species is presented here in order to indicate how slight the downward curvature of the scallops is in case of the transverse striae of some of the specimens found in the Osgood formation in Ripley county, Indiana. In the U. S. National Museum.

40. **Dawsonoceras multiliratum** Sp. nov.

Plate LX, figs. 2, 1

Specimen 190 mm. long, enlarging from a diameter of 39 mm. at its base to 45 mm. at its top. About 6, locally only 5.5 annulations occur in a length equal to the diameter of the conch. The

annulations are 3 mm. wide and 1 mm. high. Their crests are evenly rounded, and they are abruptly defined from the relatively flat interspaces. Along the top of the specimen there are no annulations for a length of 28 mm. Apparently the conch had entered on its gerontic stage. The original length of the living chamber may have extended above the part still preserved. The undulations of the transverse striae agree in location with the relatively faint vertical ribs. Of these ribs there are about 52 or 54 within the circumference of the conch, alternate ribs being slightly more prominent. Along the ribs the transverse striae curve distinctly upward, the downward curving scallops occupying the intermediate grooves. The vertical ribbing is most distinct where crossing the transverse annulations, being relatively weak in the intermediate flat spaces.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. No. 2310, Museum of Comparative Zoölogy, Harvard University.

Wauwatosa specimens.—Specimen 310 mm. long, enlarging from 43 mm. to 51 mm. in a length of 160 mm. Where the diameter is 43 mm., four and a half camerae occur in a corresponding length, increasing to 5.5 camerae where the diameter is 51 mm. The sutures of the septa occur immediately beneath the annulations along the entire length of the specimen. At several places the specimen exposes the deeply concave septa. The transverse annulations are between 3 and 4 mm. in width in a vertical direction, but are only 1.0 mm. to 1.5 mm. in height, so that they are less prominent than in *Dawsonoceras hyatti* and *Dawsonoceras nodocostatum*. The spaces between the annulations are relatively flat. There are between 65 and 75 relatively broad vertical ribs separated by narrow vertical grooves. These ribs are practically of the same size and prominence. The transverse undulating striae number 9 to 13 in a length of 5 mm. They curve upward where crossing the vertical ribs, and downward in the intermediate grooves. Wauwatosa, Wisconsin; in the Waukesha dolomite, directly beneath the Racine dolomite. No. 2311, Museum of Comparative Zoology, Harvard University.

Another specimen from the same locality and horizon is num-

bered 2309. It is 85 mm. long and includes a living chamber. The interior of this chamber was contracted for a length of about 25 or 30 mm. at a point 50 mm. below the top of the chamber. At one of the annulations within this contracted part the diameter of the conch is only 53.5 mm., while at one of the annulations farther up the diameter is 59.5 mm. The annulations are still fairly distinct within this contracted part, but become even less distinct farther up. There are 70 low vertical ribs, the transverse striae curving upward on crossing the latter.

In both figures on plate LX, the vertical ribs are strongly accentuated. Under ordinary illumination they are relatively weak.

41. **Spyroceras ruedemanni** Sp. nov.

Plate LXI, figs. 3 A–G; plate LXIII, fig. 7

Conchs relatively small, with the ventral outline distinctly convex, while the dorsal outline is straight. Compressed dorso-ventrally; the amount of this compression being evident on contrasting figure 3 B, a lateral view, with 3 A, a ventral view of the same specimen; or figure 3 D, also a lateral view, with 3 C, a dorsal view of the same specimen. The conch enlarges to within about 2 camerae of the top of the phragmacone and then contracts moderately as far as the aperture of the living chamber. The number of camerae in a length equal to the diameter of the conch at the top of the series counted averages about 7. The conch is transversely annulated. The number of these annulations in a length equal to the diameter of the conch at the top of the series counted varies usually from 5 to 5.5, but may reach 6. The sutures of the septa slope slightly downward from the dorsal toward the ventral side of the conch, but the annulations slope in an opposite direction, from the ventral toward the dorsal side. An attempt is made here to illustrate the specimens figured in such a manner as to show both the sutures of the septa and the annulations, with only moderate success. Along the living chamber the annulations become conspicuously broader and more distant from each other. Along the upper half of this chamber the cast of the interior of the conch is broadly constricted by a

thickening of the interior of the shell, as in numerous other fully mature orthoceroids. The surface of the shell was vertically striated or ribbed, these striations leaving their equivalent marks on the cast of the interior. The concavity of the septa was small. The siphuncle is nearly central in location, and is 2 mm. in diameter where the diameter of the conch in a dorso-ventral direction is 15.5 mm. Its segments enlarge only faintly within the camerae.

Locality and horizon.—Moodie quarry, in the southeastern part of Wilmington, Ohio; in the Cedarville dolomite. Specimens 3 A, B, F of plate LXI are from the Welch collection in Wilmington College; 3 C, D, G are in the Austin collection in the U. S. National Museum; and 3 E is from Walker Museum, Chicago University. Named in honor of Dr. Rudolph Ruedemann, State Paleontologist of New York.

Remarks.—It is evident, of course, that the conch here described as *Spyroceras ruedemanni* belongs to a very different group from that to which the name *Spyroceras* originally was applied. Its nearest relationship is with the species described by Foerste and Savage from the Shammatawa member of the Richmond west of Hudson Bay under the name *Spyroceras geronticum*.[2] *Spyroceras crocus* (Billings) also may be related. It is not unlikely that other species of the *Spyroceras bilineatum* type may prove related to the *Spyroceras geronticum* group when living chambers of their fully mature or gerontic forms become known. At present, however, this group is known chiefly from fragments of the phragmacone alone.

At Port Byron, Illinois, in the Port Byron member of the Niagaran, a small fragment of a conch was obtained which is closely similar to *Spyroceras ruedemanni*, if not identical with the latter. It consists of the basal part of the living chamber and of 3 camerae. The conch is depressed dorso-ventrally. The uppermost camera is conspicuously shorter than the rest, indicating that the conch was entering on its gerontic stage. The remain-

[2] Foerste and Savage, Ordovician and Silurian Cephalopods of the Hudson Bay area, Jour. Sci. Lab. Denison Univ., 22, 38, plate 6, figs. 1 A, B; plate 5, figs. 3, 2 (1927).

ing camerae suggest the presence of 6 camerae in a length equal to the lateral diameter of the conch. The conch is annulated transversely, though this is not well shown in the figure here presented, which was illuminated so as to show the vertical striae. The latter are similar to those of *Spyroceras ruedemanni*. Specimen No. 441 in the Ward collection, in the U. S. National Museum. Plate LXIII.

A specimen of *Spyroceras ruedemanni*, including the living chamber and a considerable part of the phragmacone, was found in the quarries in the Hawthorne area of western Chicago, in the Racine dolomite.

42. **Spyroceras gorbyi** (Miller)

Plate LXI, figs. 4 A, B, C

Orthoceras gorbyi Miller, 18th Ann. Rep. Dep. Geol. Nat. Res. Indiana, for 1893, 322, pl. 10, fig. 2 (1894).

Specimen about 65 mm. long, enlarging only slightly over 2 mm. in this length. It consists chiefly of the phragmacone, but retains also a part of the base of the living chamber. Along its lower part 7 camerae occur in a length equal to the diameter of the conch; farther up this number increases to 10 in a corresponding length. The conch evidently had reached full maturity and had entered on its gerontic stage. Septa very moderately concave. The sutures of the septa are directly transverse. The number of annulations within a length equal to the diameter of the conch is 5. These annulations slope strongly downward from the dorsal toward the ventral side of the conch. In addition, the surface of the shell was distinctly striated vertically, 7 striae occurring in a width of 5 mm.

Locality and horizon.—From some unknown locality in Franklin county, Indiana; from the Richmond formation, probably from the Whitewater member. No. 64337, in the U. S. National Museum.

Remarks.—Conch similar to *Spyroceras hammelli* Foerste,[3] from the Hitz layer at the top of the Saluda member of the Richmond

[3] Bull. Sci. Lab. Denison Univ., 16, 74, pl. 1, fig. 4 (1910).

as exposed at Dog Falls, on Saluda creek, southwest of Hanover, Indiana. In the latter, however, the vertical striae alternate conspicuously in size, and the annulations are less oblique. Moreover, only 4 septa were found in a length equal to the diameter of the conch.

43. **Spyroceras crocus** (Billings)

Plate LVI, fig. 8

Orthoceras perannulatum Billings (not Portlock, 1843), Geol. Surv. Canada, Rep. Progress for 1853–56, 317 (1857).

Orthoceras crocus Billings, Cat. Sil. Foss., Anticosti, 22 (1866).

Specimen 55 mm. long, consisting of the lower part of a living chamber, with 6 camerae still attached. The diameter at the base of the specimen is 18 mm., and from this it contracts to 16.5 mm. at the base of the living chamber and to 10.5 mm. at the uppermost annulation preserved. Three and a half camerae occur in a length equal to the diameter of the conch. At the lower end of the specimen 4.5 annulations occur in a corresponding length, the distance between the annulations remaining the same farther up, where the conch is narrower, the result being that the annulations appear more distantly spaced compared with the diameter of the conch. The cast of the interior of the conch is ornamented by fine vertical raised lines of which 6 primary ones occur in a width of 8 mm., less distinct secondary raised lines occurring in most of the intermediate spaces. It is estimated that about 35 raised lines occur within the circumference of the conch.

Locality and horizon.—From locality 15, visited by the expedition to Anticosti under Prof. N. S. Shaler. The specimen is regarded as either from the English Head or Vaureal member of the Richmond. No. 2289, in the Museum of Comparative Zoology, Harvard University.

Remarks.—Since the type of this species is lost, it is impossible to determine with confidence exactly what type of conch Billings had in hand during his description.

The specimen described here differs from *Spyroceras anticostiense* Foerste chiefly in the greater number of camerae and annulations in a length corresponding to the diameter of the conch, at least along the upper part of the phragmacone.

44. Spyroceras tenuiannulatum (Hall)

Orthoceras tenuiannulatum Hall, Pal. New York, 3, 345, pl. 72, fig. 1 (1859, text; 1861, plates).

Specimen 23 mm. long, enlarging from a diameter of 11 mm. to 12 mm. in a length of 14 mm., with 7 annulations in a length equal to the diameter of the conch. These annulations are about four-fifths of a millimeter wide, relatively prominent, and separated by grooves a millimeter wide. They are crossed by vertical striae, readily seen under a lens, 6 or 7 striae occurring in a width of 2 mm. No transverse striae are visible.

Locality and position.—In the shaly limestone of the Lower Helderberg group, in Albany county, New York. No. 2594, American Museum of Natural History. Type of species.

Second specimen.—Another specimen from the same locality and horizon, in the same museum, is 56 mm. long; mashed flat, with a present diameter of 13 mm. at its base, and with 8 annulations in a length equal to the present diameter. There are 6 primary vertical striae in a width of 2 mm., but these alternate with fainter secondary striae. Also numbered 2594.

KIONOCERAS Hyatt

Genotype: *Orthoceras doricum* Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, texte III, pl. 269 (1874).

Several different groups may be recognized among those species usually referred to *Kionoceras*. In one group, typified by *Kionoceras scammoni*, among American species, the conch is ornamented by conspicuous transverse striae in addition to the vertical ribs. In those specimens in which vertical striae also are present, the latter are much less conspicuous than the transverse ones. In a second group, typified among American species by *Kionoceras orus*, the grooves between the vertical ribs are occupied by more or less conspicuous vertical striae. Transverse striae may be present, but in that case are much less conspicuous than the vertical ones. In a third group, typified by *Kionoceras medullare*,

there are no conspicuous ribs alternating with relatively broad vertical grooves, but moderately stronger and weaker vertical striae alternate with each other at relatively small intervals without any appearing so prominent as to appear like ribs alternating with vertical grooves. In a fourth group, typified by *Orthoceras originale*, the surface of the shell is relatively smooth or incised at regular intervals by narrow and relatively shallow vertical grooves. However, the shell itself appears to contain numerous flat vertical lacunae, filled with matrix, separating from the inner wall of the shell in such a manner as to leave vertical grooves, alternating with vertical ribs.

The genotype of *Kionoceras*, namely *Orthoceras doricum*, as described by Barrande, includes specimens some of which could be referred to group 1 and others to group 2. The specimen figured first, represented by his figures 1 to 4, has 3 relatively conspicuous vertical striae in the grooves between the vertical ribs, while the transverse striae are much less conspicuous, as in group 2. The third group was named *Protokionoceras* by Grabau and Shimer. For the fourth group, the name *Parakionoceras* here is proposed.

The structure of the siphuncle of the various species referred to *Kionoceras* needs investigation. In most species the segments of the siphuncle are cylindrical or enlarge but slightly within the camerae. Such specimens are typified by *Kionoceras austini*, illustrated by fig. 15 on plate LXXV. In others, these segments are more or less globular in form, the structure of the siphuncle being moniliform. One of these is illustrated by figure 14 on plate LXXV. It is possible that these represent distinct generic groups, but if that be the case no other features suggesting generic distinctions have been found associated with these differences in the form of the segments of the siphuncle.

It has been noticed that in various orthoceroids the segments of the siphuncle tend to be cylindrical or to enlarge but slightly within the camerae when these camerae are relatively tall, and to be more nearly globular or even somewhat nummuloidal when the camerae are relatively short. However, there are enough exceptions to show that these differences are not constant.

45. **Kionoceras scammoni** (McChesney)

Plate LXII, figs. 1, 2; plate LXVII, figs. 2 A, B; plate LXV, fig. 4; plate LXIII, fig. 2; plate LXIV, fig. 3

Orthoceras scammoni McChesney, Descr. New Fossils, 92 (1861).
Orthoceras angulatum Hall (not Wahlenberg), 20th Rep. New York State Mus. Nat. Hist., 353, pl. 19, figs. 9, 10, 11 (1868).

Original description of *Orthoceras scammoni:*

Shell elongate, tapering somewhat rapidly, cylindrical; septa strongly convex, and distant about one-fourth the diameter of the shell; syphuncle moderately large, slightly constricted in the septa, nearly central. Surface strongly marked by equi-distant longitudinal ridges, which are about one-tenth of an inch apart, on specimens one inch in diameter; spaces between the ridges regularly concave. On well preserved specimens these ridges are crossed by fine striae or lines of growth. The ridges are distinctly preserved on cases (in some cases?). Associated with this species there is an undescribed species somewhat closely allied to it, of which I have seen no well preserved specimens, but which is easily separated from this, by the septa being distant about one-half the diameter of the shell, while in this they are only one-fourth. *Geological position and locality.* This is an abundant fossil in the Niagara limestone, at Chicago, (Bridgeport), Illinois. Named in honor of F. Scammon, M.D., Chicago, Illinois.

According to the preceding description, the number of vertical ridges within the circumference of the conch was about 31. Unfortunately the type of this species has been lost. In its absence, the following two specimens have been selected as topotypes.

Conch enlarging at a rate of 11 mm. in a length of 100 mm.; 36 mm. in diameter at its larger end. It is estimated that 36 vertical ribs occurred in the circumference of the conch. These vertical ribs are narrow and sharply crested, their crests being scarcely one-fourth of a millimeter wide. They are crossed by conspicuous transverse raised lines or striae at more or less rhythmic intervals, usually 10 striae in a length of 10 mm., but locally they may be much more crowded. In addition, from 5 to 7 very fine vertical striae may be detected in some of the grooves between the vertical ribs; these intermediate striae, however, are readily visible only under a lens, and are much less conspicuous than those of typical *Protokionoceras.* From Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 715A, Walker Museum Chicago University. Plate LXII, fig. 1.

Specimen 150 mm. long, enlarging from a diameter of 25 mm. to 37 mm. in a length of 100 mm. Four camerae occupy a length equal to the diameter of the conch. The concavity of the septa equals the height of one of the camerae. The siphuncle is subcentral. Its diameter is 6.5 mm. where the diameter of the conch is 25 mm. It is estimated that about 40 vertical ridges occupied the circumference of the conch. The crests of these ridges are relatively low and broadly rounded on the cast of the interior of the conch. This cast presents no trace of striae, either transverse or vertical. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 2297A, Museum of Comparative Zoology, Harvard University. Plate LXII, fig. 2.

In the Illinois State Museum of Natural History at Springfield, Illinois, there are several specimens from the same locality, numbered 7770, which are characterized by 40 vertical ribs. There are faint traces of transverse markings, the specimens being casts of the interior of the conchs. The rate of expansion of these specimens is about the same as in *Kionoceras scammoni*. The number of camerae in a length equal to the diameter of the conch is about 5. Plate LXVII, figs. 2 A, B.

The specimen described by Hall under the name *Orthoceras angulatum* (fig. 9, cited above), from the Racine dolomite, at Racine, Wisconsin, consists of a living chamber at least 55 mm. long, to which is attached a phragmacone 95 mm. long, including 23 camerae. It has the same apical angle as specimens here referred to *Orthoceras scammoni*. Five camerae occur in a length equal to the diameter of the conch, except at the very base of the specimen where their number is four. The number of vertical ridges is estimated at about 26. The transverse striae number slightly more than 10 in a length of 10 mm. at the smaller end of the specimen. No. 2108, in the American Museum of Natural History. Plate LXV, fig. 4.

At the conclusion of the description of *Orthoceras angulatum*, cited above, Hall made the following pertinent remarks:

> This is probably the species described by Mr. M'Chesney, in a paper published in 1861, under the names *O. scammoni*, *O. hoyi*, *O. lineolatum*, *O. irregulare*, *O. woodworthi*. The last one figured in a fragment less than an inch in length. A

gutta percha cast sent by Prof. Winchell under the name *O. scammoni*, corresponds very well with specimens referred by me to *O. angulatum*. Should the species prove distinct from the European one, we may select a name from among those above cited. The comparison of a considerable collection from Bridgeport and the various localities in Wisconsin has not convinced me that we have so large a number of species of a character so similar as those above cited.

Among the McChesney species cited above by Hall, the name *scammoni* is selected for the species represented on plate LXII by figures 1 and 2, because in the description of *Orthoceras scammoni* the vertical ridges are stated to be crossed by fine striae or lines of growth. In *Orthoceras hoyi* the conch is said to taper moderately, instead of somewhat rapidly, as in *Orthoceras scammoni*, and the vertical ridges are described as more distant. In *Orthoceras lineolatum* the number of vertical ribs is estimated to have been only 18 to 20. In *Orthoceras irregulare*, later renamed *Orthoceras Woodworthi*, 7 to 8 camerae occupied a length equal to the diameter of the conch.

In another specimen from the Racine dolomite, at Bridgeport, within the present limits of Chicago, Illinois, the apical angle is 7 degrees. The number of camerae within a length equal to the diameter of the conch at the top of the series counted varies from 4.5 at the base to 5.5 at the top. The number of vertical ribs is estimated at 32. These ribs are crossed, at intervals of one millimeter or slightly less, by low, faint, broad, transverse striations, which probably correspond to much stronger transverse markings on the exterior of the shell, but the latter is no longer preserved. No. 2216, in the Illinois State Museum of Natural History. Plate LXIII, fig. 2.

Hall's figure 10, cited above under *Orthoceras angulatum*, was prepared from a fragment of a cast of the exterior of a conch. This fragment is 65 mm. long. The conch is estimated to have had about 27 acutely angular vertical ribs within its circumference. Racine, Wisconsin; in the Racine dolomite. No. 2108B, American Museum of Natural History. Plate LXIV, fig. 3.

Anderson specimen.—Apical angle of specimen figured by Kindle and Breger,[4] 7 degrees. The number of camerae in a

[4] Kindle and Breger. 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana for year 1903, 472, pl. 21, fig. 3 (1904). Specimen identified as *Orthoceras* (*Kionoceras*) *angulatum* Wahlenberg.

length equal to the diameter of the conch is about 4. The number of vertical ridges does not appear to exceed 20. Nothing is known of the ornamentation of the surface. Compared with *Kionoceras scammoni*, the number of vertical ribs is considerably smaller.

46. **Kionoceras** sp. (Yellow Springs)

Plate LXII, fig. 6; plate LXV, fig. 3; plate LXIV, fig. 2

Conch with an apical angle of 10 degrees, enlarging from 13 to 20 mm. in a length of 35 mm. The location of the septa is unknown. The surface of the shell is ornamented by 24 vertical ribs, with rather deeply channeled intervening grooves. These are crossed by transverse striae similar to those of *Kionoceras scammoni* and *Kionoceras loxias*. In addition there are faint constrictions, 4 in a length of 26.5 mm., the diameter of the fragment at the topmost constriction being 21 mm. No. 3431 B. Plate LXII, fig. 6.

A second fragment has an apical angle of 9 degrees, is 16 mm. in diameter at its larger end, and had about 32 vertical ribs within its circumference. There also are low transverse annulations, about 4.5 in a length equal to the diameter of the conch. No. 3431 A. Plate LXV, fig. 3.

Locality and horizon. Yellow Springs, Ohio, in the Cedarville dolomite. Both specimens are in the museum at Ohio State University.

Remarks. These specimens differ from those cited above in their larger apical angle.

A third fragment is represented by a cast of the exterior of a fragment belonging to the apical end of a conch. Apical angle about 9 degrees. The number of vertical ribs within the circumference of the conch is estimated at 46. Their crests are sharply angular. Ten transverse striae occur in a length of 10 mm. at the upper end of the specimen. There are no traces of vertical striae within the grooves between the vertical ribs. About 5 weak annulations occur within a length equal to the diameter of the conch. Racine, Wisconsin; in the Racine dolomite. No.

2108 C, American Museum of Natural History. Plate LXIV, fig. 2.

47. **Kionoceras** sp. (Shelby)

Plate LXII, fig. 4

Kionoceras medullare Clarke and Ruedemann, Mem. New York State Mus., 65, 86, pl. 10, fig. 23.

Impression of exterior surface of part of one side of a specimen. Diameter estimated at 27 mm. Since 8 of the primary vertical ribs occur in a width of 21 mm. it is estimated that 28 occurred within the circumference of the conch. The primary ribs are prominent and sharp. Alternating with these primary ribs is an equal number of secondary striae, much less prominent. The transverse striae, regularly spaced, number about 7 in a length of 10 mm. Compared with the vertical markings, these transverse striae are lower, and broader, and therefore less conspicuous.

Locality and horizon.—Shelby, New York, in the Lower Shelby dolomite, a member of the Lockport. No. 12384–2, New York State Museum, at Albany, New York.

Remarks. This specimen resembles the larger one of the fragments of *Kionoceras* figured on plate LXX (fig. 4A), from St. Clair Springs, Arkansas, excepting that the primary ribs appear more prominent.

48. **Kionoceras woodworthi** (McChesney)

Plate LXIII, fig. 8

Orthoceras irregulare McChesney, Descr. New Fossils, 94 (1861).
Orthoceras Woodworthi McChesney, Plates Illustr. New Species Fossils, pl. 7, fig. 7 (1865); Trans. Chicago Acad. Sci., 53, pl. 7, fig. 7 (1868).

Original description:

Shell small, tapering rapidly; septa convex, distant from an eighth to a seventh the diameter of the shell: syphuncle very small and nearly central: from the only specimen in our possession the growth of the shell appears to have been very irregular, giving expansions and depressions in the taper of the specimen. Surface marked by sharp angular longitudinal ridges about one-tenth of an inch apart

on a specimen one inch in diameter, these ridges are indistinctly preserved on the cast. *Geological position and locality.* In Niagara limestone, Milwaukee, Wisconsin.

From the published figure it is estimated that there were about 28 vertical ribs within the circumference of the conch. The tendency toward annulation is not a specific character in the genus *Kionoceras*, but is due to some pathogenic condition of the shell, and is not unknown in occasional specimens of other species. The most characteristic feature mentioned by McChesney is the presence of 7 or 8 camerae within a length equal to the diameter of the conch.

Kionoceras myrice Hall and Whitfield has a similar number of camerae and of vertical ribs, but it is a distinctly smaller species than *Kionoceras woodworthi*.

A specimen similar to *Kionoceras myrice*, but larger in size, was found at Cedarville, Ohio, in the Cedarville dolomite, equivalent to the Racine of Wisconsin and Illinois (Plate LXIII, fig. 8). Its maximum diameter is 28 mm., and it may have attained a still larger diameter at the base of the living chamber. The number of camerae within a length equal to the diameter of the conch equals 7 along the lower part of the specimen and 7.5 farther up. No. 9444, Ohio State University. At Bowling Green, in northern Ohio, a similar specimen is 27 mm. in diameter, and has 27 vertical ribs, the latter extending upward along the living chamber.

49. **Kionoceras lineolatum** (McChesney)

Original description:

Orthoceras lineolatum McChesney, Descr. New Fossils, p. 93 (1861).

Shell elongate, tapering very gradually, nearly cylindrical, septa moderately convex, distant about one-fourth the diameter of the shell. Syphuncle of medium size and situated one-third the diameter of the shell from one side. Surface marked by strong angular ridges, distant about two-tenths of an inch, on specimens one inch and a quarter in diameter, separated by regular concave spaces; cross striae are very indistinctly seen on the specimen under description. The ridges are more distant and the spaces between them deeper than on *O. Hoyi*. *Geological position and locality.* In Niagara limestone, Joliet, Illinois.

According to the preceding description, about 19 vertical ribs occur in a length equal to the diameter of the conch. This feature *Orthoceras lineolatum* shares with *Orthoceras loxias* Hall, *Orthoceras strix* Hall and Whitfield, and *Orthoceras (Kionoceras) delphiense* Kindle and Breger. Both *Orthoceras loxias* and *Orthoceras strix* enlarge more rapidly, but *Orthoceras (Kionoceras) delphiense* is described as enlarging only 5 mm. within a length of 120 mm., and therefore might be described as enlarging very gradually, and as being nearly cylindrical. However, the interspaces between the ribs of *Orthoceras delphiense* seem to have been covered with coarse longitudinal striae, and there were also transverse striae. In *Orthoceras lineolatum*, on the contrary, no vertical striae were noted, and the cross striae were very indistinctly seen, so that it is impossible to identify *Orthoceras lineolatum* with *Orthoceras delphiense*.

50. **Kionoceras loxias** (Hall)

Plate LXII, fig. 3

Kionoceras loxias Foerste, Contrib. Mus. Geol. Univ. Michigan, 2, 29, pl. 14, fig. 1 (1924).

A figure of the type of natural size is here presented for comparison with such species as *Kionoceras scammoni*, in which the surface of the conch is conspicuously striated in a transverse direction, and in which few or no vertical striae occur within the grooves intermediate to the vertical ribs. Probably from the northwest shore of Lake Michigan, on the peninsula extending southwestward from Manistique as far as Point Detour; in the Manistique member of the Niagaran. No. 2105, in the American Museum of Natural History.

51. **Kionoceras strix** (Hall and Whitfield)

Plate LXVII, fig. 1; plate LXVI, fig. 1

Orthoceras strix Hall and Whitfield, Geol. Surv. Ohio, Pal., 2, 149, pl. 9, fig. 3 (1875).

Conch enlarging at an apical angle of nearly 9 degrees, the diameter at its base being 37 mm., and the length of the speci-

men 183 mm., judging from the figure cited above. The number of camerae within a length equal to the diameter of the conch at the top of the series counted varies from 3.4 along the lower third of the specimen to 4.2 along its middle third, and 4.75 along its upper third. The number of vertical ribs within the circumference of the conch is 16 or 17. In the original description it is stated that the surface of the shell apparently has been longitudinally striated in the flutings, as is shown by a fragment of shell adhering to the cast in the depression on one of the flutings, but no evidence of transverse striae was seen.

Locality and horizon.—Yellow Springs, Ohio; in the Cedarville dolomite, which is equivalent to the Racine of Wisconsin and Illinois. The type appears to be lost.

A closely related specimen was found in the Cedarville dolomite at some unknown locality in Greene county, Ohio. Its apical angle is 9 degrees, its width being 40 mm. at the top. The number of camerae within a length equal to the diameter of the conch at the top of the series counted is slightly less than 4. There are 18 vertical ribs. The crests of these ribs are sharply angular, though the depth of the intervening grooves is scarcely half a millimeter. These crests are formed by sharply elevated lines. In the intervening grooves there are 7 less conspicuous striae, of which the alternate 3 are stronger than the other 4. Along one part of the specimen there are traces of very faint transverse markings of which 8 occur in a length of 10 mm. These markings are low and too broad to be called transverse striae. No. 3160, in museum of Ohio State University. Plate LXVII, fig. 1.

A specimen from the Wabash valley of northern Indiana consists of the greater part of a living chamber with a considerable part of the phragmacone still attached. Its apical angle is 9 degrees. The number of camerae within a length equal to the diameter of the conch at the top of the series counted is 5, except at the top of the phragmacone, where the last two or three camera are distinctly shorter than those just beneath, indicating that the conch had attained full maturity. The number of vertical ribs within the circumference of the conch is 19 or 20. There

are distinct traces of vertical striae, 7 or 8 occurring within each groove intermediate to the ribs. No. 7304, U. S. National Museum. Plate LXVI, fig. 1.

52. **Kionoceras** cf. **strix** (Hall and Whitfield)

Plate LXIII, fig. 9

Specimen consisting of a living chamber with two camerae still attached. The apical angle is nearly 10 degrees. Of the living chamber only the lower part, 51 mm. long, is preserved. The lateral diameter at the base of the chamber is 52 mm., and the dorso-ventral one is 47 mm. The number of camerae in a length equal to the diameter of the conch at the top of the series counted is estimated at 4. The septa slope slightly downward, presumably from the dorsal toward the ventral side of the conch. The number of vertical ribs within the circumference of the conch is 18. Only the cast of the interior of the conch is preserved, and on this cast the crests of the vertical ribs are fairly distinct, though low and broadly rounded; the intervening grooves are shallow. No trace of the surface ornamentation of the shell remains.

Locality and horizon.—Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 189, in the collection of Prof. T. E. Savage.

Remarks.—In its apical angle, the relative number of its camerae within a length equal to the diameter of the conch, and in the number of its vertical ribs, this specimen resembles *Kionoceras strix*, from the Cedarville member of the Niagaran. In the absence of any knowledge of the surface ornamentation of the Port Byron specimen, this identification can not be made with certainty.

53. **Kionoceras delphiense** (Kindle and Breger)

Orthoceras (*Kionoceras*) *delphiense* Kindle and Breger, 28th Ann. Rep. Dep. Geol. Nat. Res. Indiana, 470, pl. 20, figs. 1, 2 (1904).

The type specimen is described as 162 mm. long, the diameter enlarging from 45 mm. to 50 mm. within a length of 120 mm.,

the latter diameter being at the aperture. Nothing is known of the relative number of camerae within a length corresponding to the diameter of the conch. The number of vertical ribs is estimated at about 18. The interspaces seem to have been covered with coarse vertical striae. There are also transverse striae. The siphuncle is strongly excentric in location.

Locality and horizon.—Delphi, Indiana; in Niagaran limestone. Type, in the Indiana State Museum.

54. **Kionoceras mcchesneyi** Sp. nov.

Plate LXV, figs. 2, 1

Conch enlarging at the rate of 9 mm. in a length of 100 mm., the apical angle slightly exceeding 5 degrees. At the top of the specimen, its maximum diameter is 60 mm. Only the lower part of the specimen here is figured. Since the uppermost camera is distinctly shorter than those immediately beneath, this specimen may be regarded as fully mature. The number of camerae within a length equal to the diameter of the conch is 4. The sutures of the septa slope moderately downward from the dorsal toward the ventral side of the conch, but this may be due to the compression of the latter after the death of the animal. The concavity of the septa equals 11 mm. where the diameter of the conch is 35 mm. The siphuncle is located slightly ventrad of the center of the conch. The diameter of the siphuncle here is 6 mm., and its segments are cylindrical. The lower part of the specimen, for a length of 80 to 90 mm., preserves the shell. This varies in thickness from half a millimeter along the vertical grooves to over one millimeter along the crest of the intermediate ribs. The number of vertical ribs is 19. Under favorable cross-illumination, faint vertical striae are seen within the grooves between the ribs, apparently about 7 or 8 in each grove.

Locality and horizon.—Joliet, Illinois, in the Joliet member of the Niagaran. No. 18109, in Walker Museum, at Chicago University.

Remarks.—Among the various species of *Kionoceras* and *Protokionoceras* described by McChesney from the Niagaran of

Illinois and Wisconsin, only *Orthoceras lineolatum* was described from Joliet. With that species, *Orthoceras mcchesneyi* agrees in its rate of enlargement, in the relative number of its camerae within a length equal to the diameter of the conch, and in the number of vertical ribs within the circumference of the conch. However, only transverse striae are mentioned in the description of *Orthoceras lineolatum*, and only vertical striae are seen on the type of *Kionoceras mcchesneyi*.

From *Orthoceras* (*Kionoceras*) *delphiense* Kindle and Breger it differs in having a much smaller and much more centrally located siphuncle. Nothing is known of the relative number of camerae in the Indiana species.

A somewhat similar specimen was found at Lennon, Waukesha county, Wisconsin, in the Waukesha dolomite. It is 190 mm. long, and enlarges from 32 mm. at its base to 44 mm. at its top. It is strongly flattened by pressure after death of the animal. The number of camerae within a length equal to the diameter of the conch varies from 3.5 to 4 camerae in different parts of the phragmacone. The number of vertical ribs is 18 or 19. On the cast of the interior of the conch these ribs are broadly rounded, but on the surface of the shell the crest of these ribs is occupied by a single raised striation less than half a millimeter in width, the ribs themselves being sharply angular. The grooves between these crests are occupied by 11 to 16 very narrow vertical striae, readily seen only under a lens. No. 4706, in the Public Museum of Milwaukee, Wisconsin.

This Lennon specimen may prove distinct from that found at Joliet, but it evidently is closely related.

55. **Kionoceras multiseptatum** Sp. nov.

Plate LXVII, fig. 5

Specimen 77 mm. long, of this length 46 mm. belongs to the living chamber. The conch enlarges at a rate not exceeding 4 degrees, possibly less. Its diameter at the base of the living chamber is 28 mm. Between 23 and 37 mm. above this base the living chamber is strongly constricted. The number of cam-

erae in a length equal to the diameter of the conch is 8. The surface of the conch was ornamented by 18 vertical ribs, reduced to a narrow line along their crests. No trace of either vertical or transverse striae remains in the grooves between the ribs.

Locality and horizon.—Wauwatosa, Wisconsin; in the Waukesha member of the Niagaran. No. 621, in the Public Museum of Milwaukee, Wisconsin.

Remarks.—The species of *Kionoceras* that have approximately 18 vertical ribs are *Kionoceras lineolatum* McChesney, *Kionoceras loxias* Hall, *Kionoceras strix* Hall and Whitfield, and *Kionoceras delphiense* Kindle and Breger. Of these the three named first have about 4 camerae in a length equal to the diameter of the conch. Nothing is known of the camerae in the one named last. *Kionoceras mcchesneyi*, described here, also has only 4 camerae within the length here designated. Compared with these, the number of camerae in the Milwaukee specimen is distinctly greater.

56. **Kionoceras myrice** (Hall and Whitfield)

Plate LXIII, figs. 4, 3, 5

Cyrtoceras myrice Hall and Whitfield, Geol. Surv. Ohio, Pal. 2, 149, pl. 8, fig. 9 (1875).

Conch slightly curved lengthwise, the convex side assumed to be ventral. The dorsal side is almost straight. Cross-section circular toward the apical end, slightly depressed dorso-ventrally toward the living chamber. Ratio of dorso-ventral to lateral diameter, at base of living chamber, nine to ten sometimes increasing to eight to nine. Casts of interior of conch constricted along the upper part of the living chamber, but beneath the aperture, thus indicating a thickening of the inner surface of the shell at this point. On lateral view, the sutures of the septa along the upper part of the phragmacone appear to slope distinctly downward from the dorsal toward the ventral side of the conch. The location of the siphuncle is central or slightly ventrad of the center. Its diameter is 3 mm. where the diameter of the conch is 26 mm., and its segments are cylindrical, or nearly so. The cast of the interior of the conch is marked by low, broad, vertical

ribs separated by distinct, though shallow grooves, equal or larger in width than the ribs. The type specimen is described as having 27 of these ribs, but their number usually varies from 25 to 29. The number of these ribs is constant in the same individual at all stages of its development, except possibly at its extreme apical end, which so far has not been found.

Locality and horizon.—Originally described from Yellow Springs, Ohio; in the Cedarville dolomite. Now most numerous at Cedarville, Ohio. Occasional specimens occur at the Moodie quarry in Wilmington, Ohio. The location of the type of this species is unknown.

Remarks. Notwithstanding the numerous specimens of this species which have been found, nothing is known of the character of the ornamentation on the surface of the shell. Usually only the casts of the interior of the conch are collected, and the few specimens that presented casts of the exterior of the shell are too strongly dolomitized to preserve the surface ornamentation. The typical specimens of *Kionoceras myrice* are of small size. However, owing to the constriction of the upper part of casts of the interior of their living chambers, corresponding to a thickening of the interior of the shell, these small conchs are assumed to have been mature.

There appears to be considerable variation in the number of vertical ribs in different individuals. At Cedarville, Ohio, one specimen was found with 36 vertical ribs. It increased from 16 to 20 mm. in a length of 25 mm.; 7.5 camerae occupied a length equal to the diameter of the conch at the top of the set. The siphuncle was nearly central, and moniliform. Its segments increased in diameter from 1.5 mm. at the septa to 2.5 mm. at mid-height of the camerae. Plate LXXV, fig. 14. At the Moodie quarry in Wilmington, Ohio, several specimens were found which had as low as 21 vertical ribs. All of these specimens agree in having usually from 7.5 to 8.5 camerae in a length equal to the diameter of the conch, but occasionally a specimen occurs in which only 6.5 camerae occur in this length. Even in these small specimens the upper part of the living chamber is constricted on its interior, as in the much larger individuals.

In the quarry at Cedarville, Ohio, in the Cedarville dolomite, a living chamber was found which is similar to *Kionoceras myrice* in the number of its vertical ribs, 25 within the circumference of the conch, and in the dorso-ventral depression of this conch. The suture of the septum at the base of this chamber slopes distinctly downward from the dorsal toward the ventral side. However, the conch is much larger than in typical *Kionoceras myrice*, and the constriction above mid-height of the chamber is much more conspicuous. Plate LXIII, fig. 5.

57. **Kionoceras** sp. (Port Byron)

Plate LXII, fig. 5

Specimen consisting of part of a living chamber 28 mm. long, to which a single camera 1.7 mm. in length is attached. The top of this specimen retains the lower part of the constriction characterizing the upper part of the living chamber of mature stages of the conch in many orthoceroids. It is estimated that the original length of this living chamber was about 35 mm. The specimen is depressed dorso-ventrally, its lateral diameter at the base being 22 mm., the corresponding dorso-ventral one being 19 mm. The sutures of the septa slope downward from the dorsal toward the ventral side of the conch at an angle of 9 degrees with a horizontal plane. The center of the siphuncle is located 7.5 mm. from the ventral wall of the conch. The rate of enlargement of the conch is very small, equalling apparently 1.5 degrees. The number of vertical ribs within the circumference of the conch is 28. No trace of surface striae is preserved.

Locality and horizon.—Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 439 in the Ward collection in the U. S. National Museum.

Remarks.—As far as the number of vertical ridges are concerned this specimen could be referred to *Kionoceras myrice*, but the living chamber is relatively longer, and it enlarges at a smaller apical angle, as far as can be determined from the small fragment at hand.

58. **Kionoceras austini** Sp. nov.

Plate LXIV, fig. 4; plate LXIII, figs. 1, 6

Specimen consisting of a phragmacone 187 mm. long and of the basal part of the living chamber 30 mm. long. This basal part of the living chamber is omitted in the figure here presented. The phragmacone enlarges from 29 mm. at its base to 46 mm. at its top. The conch is faintly curved lengthwise, the convexity of its ventral outline equalling only 2 mm. at its maximum point. The number of camerae in a length equal to the diameter of the conch averages about 6. On lateral view the sutures of the septa slope more or less distinctly downward in a ventrad direction, especially along the upper part of the phragmacone. There are 25 vertical ribs within the circumference of the conch. The crests of these ribs, as seen on the cast of the interior of the conch, are broadly rounded, rising scarcely half a millimeter above the intervening grooves at the larger end of the specimen. Plate LXIV, fig. 4.

In a second specimen, 40 mm. in diameter at the top, there are 6 camerae in a length equal to the diameter of the conch, but there are only 20 vertical ribs. The siphuncle is 5.5 mm. in diameter where the diameter of the conch is 32 mm., and its segments are very nearly cylindrical, being narrowed slightly at the septa. Plate LXIII fig. 1.

In a third specimen, 30 mm. in diameter at the top, there are 5 camerae in a length equal to the diameter of the conch. Plate LXIII, fig. 6.

Locality and horizon. The type specimen, mentioned first, is in the Austin collection in the U. S. National Museum. The other two are in the Welch collection, deposited in Wilmington College, at Wilmington, Ohio. All are from the Moodie quarry, in the southeastern part of Wilmington, Ohio. Named in honor of Dr. George M. Austin, of Wilmington, Ohio.

Remarks.—Unfortunately nothing is known of the character of the ornamentation of the surface of this shell.

59. **Kionoceras carltonense** (Whitfield)

Orthoceras carltonense Whitfield, Geol. Wisconsin, 4, 318, pl. 24, fig. 5 (1882).

Conch enlarging at an apical angle of 6 or 7 degrees. The number of camerae within a length equal to the diameter of the conch is 8. There are 24 vertical ribs within the circumference of the conch. Nothing is known about the character of the ornamentation of the surface of the shell, nor about the structure of the siphuncle.

Locality and horizon.—Carlton, Kewaunee county; also at Ozaukee, Wisconsin. The former of these localities is located at the southern end of the southern peninsula separating Green Bay from Lake Michigan. The horizon probably is that of the Manistique formation. The type described by Whitfield is lost.

60. **Kionoceras orus** (Hall)

Plate LXIV, figs. 1, A, B, C

Orthoceras columnare Hall, 20th Rep. New York State Cab. Nat. Hist., 351, pl. 19, figs. 4–8 (1868); not *Orthoceras columnare* Marklin (1857).

Orthoceras orus Hall, in Miller, Palaeozoic Fossils, 1st ed., 245 (1877).

Three specimens were figured by Hall under *Orthoceras columnare*. Of these, the original of his figure 6 here is selected as the type, since this is the only one of his specimens which preserves the smaller vertical striae on the surface of the shell. Apical angle 7 degrees. At the lower and upper ends of this specimen the camerae occur at a rate varying between 3.25 and 3.5 in a length corresponding to the diameter of the conch, increasing above its middle to 4 camerae in a corresponding length. Apparently there was a retardation in the rate of growth of the animal, followed by rejuvenation. The cast of the interior of the conch is marked by low vertical ribs. It is estimated that about 27 of these ribs occurred within the circumference of the conch. At the top of the specimen a small fragment of the shell is preserved.

This shell thickens and becomes more angular immediately over the crests of the vertical ribs as seen on casts of the interior of the conch. The latter are low, broadly rounded, and relatively faint, while the vertical ribs on the surface of the shell are rather sharply angular. The crest of these sharply angular ridges on the surface of the shell is formed by a single coarse raised striation, the concave intermediate spaces being occupied in each case by 4 or 5 striae which are somewhat less conspicuous. There are no indications of transverse striae; if present, they must be very much less distinct than the vertical ones (fig. 1 B).

The original of Hall's figure 8 is only 29 mm. in diameter at its upper end. In this specimen the number of camerae within a length equal to the diameter of the conch only slightly exceeds three (fig. 1 C).

The original of Hall's figure 4 differs conspicuously from the other two in the much greater length of its camerae, the number of camerae occurring within a length equal to the diameter of the conch equalling about two and a fifth. The diameter of the specimen at its top equals 45 mm. The number of vertical ribs is estimated at 27. The depth of the concavity of the septum at its lower end is 11 mm., and the diameter of the siphuncle here is 8 mm. The location of the siphuncle is almost central. In its general appearance this specimen is similar to the other two figured by Hall, and it is assumed to belong to the same species; however, in the absence of the surface striae this can not be affirmed with certainty (fig. 1 A).

Locality and horizon.—Racine, Wisconsin; in the Racine dolomite. No. 2106, in the American Museum of Natural History.

Wabash specimen.—The specimen figured by Kindle and Breger[5] from the Niagaran dolomite at Wabash, Indiana, under the name *Orthoceras (Kionoceras) orus* has an apical angle of 5 degrees, the number of camerae in a length equal to the diameter of the conch varies from 5 at the base to slightly over 4 farther up, and the number of vertical ribs was about 20. Nothing is known of the

[5] Kindle and Breger, 28th Ann. Rep. Geol. Natl Hist. Res. Indiana, for year 1903, 469, pl. 21, fig. 1.

ornamentation of the surface of the shell. Under these circumstances it can not be identified with confidence with the Racine species.

61. **Kionoceras** sp. (Huntingdon)

Orthoceras (*Kionoceras*) *orus* Kindle and Breger, 28th Ann. Rep. Geol. Nat. Res. Indiana, for year 1903, 469, pl. 25, fig. 2 (1904).

The specimens at hand consist of living chambers, some of which have 1 or 2 camerae attached. The best of these was figured by Kindle and Breger. The diameter at its base is 35 mm., but in other specimens it equals 40 mm. The constriction of the cast of the interior of the living chamber is from 2 to 3 mm. in depth and extends for a length of 25 mm., beginning at a point between 28 and 32 mm. above the base of this chamber. Judging from the length of the camerae at the top of the phragmacone, the number of these camerae in a length equal to the diameter of the conch equals about 7. The concavity of the septa has a radius of 22 mm. The siphuncle is subcentral in location, and its diameter is somewhere between 3 and 4 mm. The number of ribs within the circumference of the conch was about 21 or 23. Nothing is known of the character of the ornamentation of the surface of the shell.

Locality and horizon.—Huntingdon, Indiana; in the Niagaran dolomite. No. 52951, U. S. National Museum.

Remarks.—Compared with *Kionoceras orus*, these specimens from Huntingdon enlarge much more slowly, the number of camerae in a length equal to the diameter of the conch is greater, and the number of vertical ribs is less.

62. **Kionoceras hoyi** (McChesney)

Orthoceras hoyi McChesney, Descr. New Fossils, 92 (1861).

Original description:

Shell elongate, tapering moderately, septa convex and distant a little more than one-fourth the diameter of the shell; syphuncle cylindrical or slightly expanding in the chambers, comparatively small. Surface marked by longitudinal ridges, distant one-sixth of an inch, on specimens one and a half inches in diameter, preserved on casts; spaces between them regularly concave. This

species differs from *O. Scammoni*, in the syphuncle being less central and proportionally less; septa more distant, and the longitudinal ridges more distant. *Geological position and locality.* In the Racine limestone, (Upper Silurian), Racine, Wisconsin.

This species, according to the preceding description, had about 28 vertical ribs. In contrast with *Orthoceras scammoni* it tapered *moderately*, instead of *somewhat rapidly*, and the septa were more distant. In these respects it agreed with *Orthoceras columnare* Hall, later renamed *Orthoceras orus* Hall, described from the same locality and horizon, namely at Racine, Wisconsin, in the Racine dolomite. However, in *Orthoceras orus* the character of the surface markings is known definitely, while in the description of *Orthoceras hoyi* no reference is made to these markings. Moreover, it is not certain that *Orthoceras hoyi* is identical with the species *Orthoceras orus*, and in the absence of the type it never will be possible to determine this with confidence. Under these circumstances it is preferable to drop the name *Orthoceras hoyi* altogether.

63. **Kionoceras fililineatum** Sp. nov.

Plate LXVIII, figs. 2, 1; plate XLIX, fig. 3

Conch fairly large. Living chamber apparently attaining a length of 155 mm. in specimens varying from 38 to 45 mm. in diameter in different individuals. None of the casts of the interior of the living chambers examined show the broad constriction along their upper parts, a short distance beneath the aperture, usually seen in fully mature orthoceroid conchs. The conchs enlarge at a rate of 8 to 11 mm. in a length of 100 mm. along the phragmacone, the rate of enlargement along the living chamber often being a little less than along the phragmacone. One phragmacone, 150 mm. long, is slightly depressed dorsoventrally, and is faintly curved lengthwise, the amount of curvature of the concave outline equalling about 1.5 mm. The number of camerae in a length equal to the diameter of the conch equals about 4. The sutures of the septa are directly transverse. The concavity of the septum at the base of the living chamber has a radius of 18 mm. The location of the siphuncle is subcen-

tral. At the base of the living chamber, where the diameter of the conch is 40 mm., that of the siphuncle is 8 mm. The septal funnels are 2 mm. long, their lower margins invaginating into the top of the connecting siphonal rings. The segments of the siphuncle are cylindrical. The cast of the interior of the conch is marked by 40 low vertical ribs, separated by very shallow broad grooves, crossed at more or less regular intervals by much less distinct transverse lines of which about 7 occur in a length of 10 mm. In addition to these more regularly spaced transverse lines there are also more irregularly spaced transverse wrinkles and shallow short constrictions on some of the specimens. The shell itself is very thin, scarcely exceeding one-fifth of a millimeter in thickness. The markings on the surface of this shell, corresponding to the markings on the cast of the interior, are narrower and more sharply defined. The vertical primary ribs are formed by a single raised filiform striation from one-fourth to one-third of a millimeter in width and elevation. The broad and very shallow grooves between these vertical ribs are occupied by 3, 4 or 5 inconspicuous vertical striae, readily visible only under a lens. The transverse striae are noticed readily only when illuminated in a direction parallel to the length of the conch.

Locality and horizon.—Bridgeport (Chicago), Illinois; in the Racine member of the Niagaran. Specimen No. 25852 (plate LXVIII, fig. 2) is in the U. S. National Museum. Specimens No. 2295 (plate LXVIII, fig. 1), 2297 and 2282 (plate XLIX, fig. 3) are in the Museum of Comparative Zoölogy, at Harvard University.

Remarks.—Compared with *Protokionoceras medullare* from the Racine of Wisconsin, this species has much finer primary vertical ribs, and the intermediate ribs are more numerous and much less conspicuous. The transverse striae also are much less conspicuous. The height of the camerae is lower, and the shell is much thinner. Compared with *Protokionoceras crooki* from the Joliet member of the Niagaran, this species does not have the conspicuous alternation of more prominent primary vertical striae with an equal number of secondary ones, nor equally conspicuous transverse markings.

64. **Kionoceras rochesternese** Sp. nov.

Orthoceras virgatum? Hall, Pal. New York, 2, 291, pl. 63, figs. 3, 2a, b (1852).

Specimen 83 mm. long, possibly all belonging to the living chamber since no trace of the septa is present. Enlarging at an apical angle of 6 degrees, the diameter at its top being 37 mm. The specimen is mashed flat, but this is in a direction vertical to the stratification of the shale; parallel to the bedding the original diameter of the conch has been maintained with little change. The number of vertical ribs within the circumference of the conch is estimated at 32. These ribs are narrow and not prominent. Usually there is a vertical striation or faint raised line along the middle of the intermediate vertical grooves. These vertical markings are crossed by minute transverse lines, about 12 in a length of 2 mm., visible only under a lens and with cross-illumination. Within the compressed grooves along one edge of the specimen there are traces of equally minute vertical lines, from 5 to 7 between the primary ribs and the intermediate secondary striae.

Locality and horizon.—Described as from Rochester, New York; in the Rochester shale. Listed by Whitfield and Hovey as from Lockport, New York, but without any information as to the reason for this change in the citation of locality. No. 1810, American Museum of Natural History. Figure 3 of Hall, cited above.

Second specimen.—The original of Hall's figs. 2a, b, cited above; from the same locality and horizon as the preceding; also numbered 1810. Specimen 70 mm. long; 60 mm. wide in its present condition, mashed nearly flat, but this was probably its original diameter, before the imbedding shales were compressed. It is estimated that about 120 vertical ribs occur within the circumference of the conch. These are subequal in size, but on the right side of the specimen as figured by Hall it is possible to note a slightly greater prominence in every fourth rib. This makes possible an interpretation involving the presence of 30 primary vertical ribs, alternating with 30 secondary ribs, and

these two sets with 60 tertiary ribs. There are also traces of intermediate vertical striae, visible only under a lens, about 7 between one of the tertiary ribs and the neighboring primary or secondary rib, but these traces are visible only in two or three small areas. Transverse markings are more readily visible, especially along the right margin of the specimen, where the shell is compressed vertically to the stratification. The coarser transverse wrinkles number here about 6 in a length of 2 mm. In addition there appear to have been faint transverse striae, about as numerous as in the preceding specimen, but only vaguely indicated. It is possible that this specimen belongs to the same species as the preceding, but there is no certainty. As far as the number of vertical ribs is concerned, it is not uncommon in vertically ribbed species of *Kionoceras* to find single vertical striae appearing at younger stages of growth along the median part of the grooves between the primary ribs. At later stages of growth these striae develop into secondary ribs, and in a similar manner tertiary ribs may originate at still later stages of growth.

Remarks.—These specimens were doubtfully referred by Hall to *Orthoceras virgatum* Sowerby. The conch of the latter enlarges at an apical angle of 8 degrees. There are from 30 to 35 vertical ribs within the circumference of the conch. The finer ornaments, according to Foord, consist of exceedingly fine transverse arched striae between the ribs, visible only under a lens. No trace of smaller vertical ridges between the larger ribs have been discovered. Apparently these two species are closely related, though not necessarily identical.

65. **Protokionoceras crooki** Sp. nov.

Plate LXIX, fig. 2; plate LXX, figs. 3 A, B; 4 A, B, C

Orthoceras medullare (?) Meek and Worthen, Geol. Surv. Illinois, 6, 504, pl. 26, fig. 1 (1875).

Conch enlarging at a rate of 8 mm. in 100 mm., or at an apical angle of 5 or 6 degrees. Compressed after death of animal so as to have an elliptical cross-section with diameters of 25 and 30 mm. at its top. Sutures of septa directly transverse. The num-

ber of camerae in a length equal to the diameter of the conch at the top of the series counted averages about 3. The concavity of the septa is 9 mm. where the diameter of the conch is 30 mm. At this point the diameter of the siphuncle is 7 mm. Its segments are cylindrical. The surface of the shell is ornamented by numerous vertical and transverse striae. Of the more prominent vertical striae there are about 35 within the circumference of the conch, alternating with an equal number of less prominent secondary striae. Alternating with these primary and secondary striae there is a tertiary series, about 70 in number, not readily visible except under a lens. The transverse striae are much lower, broader, and less distinct than the more prominent vertical striae, nevertheless they form a conspicuous feature of the surface ornamentation. They occur at regular intervals and number from 9 to 13 in a length of 10 mm. in different parts of the specimen. Shell apparently very thin, since even the tertiary vertical striae have left their impress on the specimen, which is a cast of the interior of the conch.

Locality and horizon.—Joliet, Illinois; in the Joliet member of the Niagaran. No. 7766, in the Illinois State Museum of Natural History. Plate LXIX, fig. 2. Named in honor of Dr. A. R. Crook, of the Illinois State Museum of Natural History.

Remarks. The shell of *Protokionoceras crooki* differs from that of *Protokionoceras medullare* in being much thinner, and in therefore preserving the surface ornamentation on the cast of its interior. The vertical striae differ much more conspicuously in size.

Two smaller specimens from the same locality and horizon enlarge at an apical angle of 6.5 mm., and attain maximum diameters of 31 mm. Of the vertical striae, none are sufficiently prominent to suggests ribs. The more prominent or primary striae are two-fifths of a millimeter in width and number 40 within the circumference of the conch. Alternating with the latter are 40 secondary striae, one-sixth of a millimeter in width, and much less prominent than the primary ones. Traces of still finer vertical striae are present. All of these vertical striae

are crossed by transverse striae at rhythmic intervals of 7 to 9 in a length of 10 mm., but these transverse striae are not as sharply defined as the vertical ones. No. 22918, Walker Museum, Chicago University. Plate LXX, figs. 3 A, B.

A third specimen from Joliet, Illinois, also numbered 22918 in Walker Museum, Chicago University, does not preserve the surface structure well, but exposes the siphuncle. Plate LXVII, fig. 3.

Three small fragments of a species found in the St. Clair limestone at St. Clair, Arkansas, may prove distinct when the interiors of this species become known, but their exteriors are closely similar to the specimens here described as *Protokionoceras crooki*. The smallest fragment enlarges from a diameter of 13 mm. to 17 mm. in a length of 33 mm. The larger one enlarges from 29 mm. to 36 mm. in a length of 63 mm. Both indicate an apical angle of 6.5 degrees. The surface of the smallest specimen is ornamented by 33 primary vertical striae alternating with an equal number of much finer secondary striae, which occupy the median line of the flat field between the primary ribs. In the largest specimen there are a few faint tertiary vertical striae, rather irregularly distributed, usually not more than 1 or 2 between any two adjacent primary and secondary striae. In the smaller specimen these vertical striae are crossed at rhythmic intervals by elevated lines of growth, 11 in a length of 1 mm. In addition there are numerous very fine transverse lines, 12 in a length of 1 mm., visible only under a lens. In the larger specimen the elevated lines of growth number 7 or 8 in a length of 10 mm., the finer transverse lines numbering 7 or 8 in a length of 1 mm. No. 22942, in Walker Museum, Chicago University. Plate LXX, figs. 4 A, B, C.

66. **Protokionoceras medullare** (Hall)

Plate LXIX, fig. 1

Orthoceras medullare Hall, 20th Rep. New York State Cab. Nat. Hist., 353, pl. 20, figs. 1, 2; p. 381 (1868).

Specimen 295 mm. long, compressed after death of the animal so as to have an elliptical cross-section. In its present condi-

tion its maximum and minimum diameters at mid-length are 65 mm. and 52 mm. respectively. Apical angle 7.5 degrees. From 3 to 3.3 camerae occupy a length equal to the diameter of the conch at the top of the series of camerae counted. The sutures of the septa are directly transverse. The septa are deeply concave, but the siphuncle is not exposed. The shell is about 1 mm. thick. The cast of the interior of the conch is smooth. The surface of the shell is ornamented with numerous vertical striae differing in prominence. The more prominent or primary striae are estimated at 70 within the circumference of the conch. Alternating with these are an equal number of secondary striae, which are almost as prominent as the primary ones. Intermediate between these two sets of striae is a tertiary series, about 140 in number, usually very inconspicuous, not always distinctly defined in all the intervals where they might be expected. These vertical striae are crossed, at approximately regular intervals, by low transverse striae, about 6 or 7 in a length of 10 mm., which are broader than the primary vertical striae, but far less conspicuous. Both the transverse striae, just mentioned, and the intervening spaces are crossed by much finer transverse striae, visible only under a lens, of which about 9 or 10 occur in a length of 3 mm.

Locality and horizon.—Waukesha, Wisconsin; in the Racine dolomite. No. 2102, in the American Museum of Natural History.

In a small fragment of a conch from Bridgeport (Chicago), Illinois, a part of the surface of a shell is preserved. The original diameter of the conch was about 50 mm. The vertical striae are coarse, nearly equidistant, and of nearly the same prominence. Every fourth vertical stria is a little more prominent. The middle one of the three intermediate striae is next in prominence. The number of the more prominent striae within the circumference of the conch is estimated at 34, hence a total of about 136 striae might be expected, including all sizes. A little over 10 vertical striae occur in a width of 10 mm. No. 22910, Walker Museum, Chicago University. Plate LXX, fig. 2.

67. **Protokionoceras striaelineatum** (McChesney)

Orthoceras striaelineatum McChesney, Descr. New Fossils, 94 (1861).

Original description:

Shell elongate, tapering moderately; septa regularly convex, though not strongly so, distant about one-fourth the diameter of the shell. Syphuncle large, very slightly expanding in the chambers, except in the center where it is depressed. These expansions and depressions are so slight that the general appearance of the syphuncle is cylindrical. Outer shell thin. Surface beautifully marked by numerous fine longitudinal striae of which some are coarser than others. *Geological position and locality.* In Niagara limestone, Chicago (Bridgeport), Illinois.

Hall came to the conclusion[6] that McChesney's species *Orthoceras striaelineatum* was identical with his own species *Orthoceras medullare*, but he does not state upon what evidence he formed this conclusion. He gives the respective dates of publication as *Orthoceras medullare*, Feb., 1860, and *Orthoceras striaelineatum*, Feb. 1861. Orthoceras medullare is cited as published by Hall in the Report of Progress Geol. Survey Wisconsin, for 1859 (published in Feb., 1860).

As a matter of fact, McChesney's description is not sufficient to make it possible to identify his species in the absence of the type, and that is the best reason for dropping the name *striaelineatum*.

68. **Protokionoceras** sp. (Joliet)

Plate LXX, fig. 1

Specimen enlarging at an apical angle of 6 degrees, from 45 mm. at the smaller end to 60 mm. at a point 140 mm. farther up. Cross-section circular. At the lower end of the specimen the number of camerae within a length equal to the diameter of the conch is nearly 3, increasing to nearly 4 farther up. The sutures of the septa are directly transverse. The concavity of the septa is 12 mm. where the diameter of the conch is 45 mm. Here the siphuncle is central in location and 9 mm. in diameter. The most characteristic feature of the surface of the shell is the fineness of

[6] Hall, 20th Rep. New York State Cab. Nat. Hist., pp. 381, 353.

the vertical striae, without any strong contrast between stronger and weaker ones. Every fourth striation tends to be slightly more prominent that the 3 intermediate ones. At the lower end of the specimen 21 striae occur within a width of 10 mm.

Locality and horizon.—Labelled as coming from Joliet, Illinois. No. 22969, Walker Museum, Chicago University.

PARAKIONOCERAS Gen. nov.

Genotype: *Orthoceras originale* Barrande.

Conch with a relatively smooth surface, vertically incised at regular intervals by very narrow and shallow grooves. The interior of the conch appears to have been occupied by very flat vertical lacunae, at present filled by matrix. These lacunae occupy the interior of the shell itself in the spaces intermediate between adjacent shallow narrow vertical grooves just mentioned. In the present condition of the shell, its outer layer and the matrix filling the interior of the lacunae peel readily away from the interior part of the shell, thus leaving relatively broad vertical grooves, alternating with much narrower vertical ridges. These ridges correspond to the partitions between adjacent lacunae. The grooves left by the peeling off of the exterior part of the shell and the matrix filling the interior of its lacunae are not conspicuously striated, either vertically or horizontally, but under a lens minute striations may be detected.

It is possible that the shell of this conch consists of three layers, the middle one being more or less interrupted in a lateral direction by vertical constrictions or grooves. However, as here interpreted, the space along the middle part of the shell is occupied by lacunae. It is possible that a microscopic study of the shell might give evidence on this subject.

This genus includes also *Orthoceras striato-punctatum* Münster, figured by Barrande on his plates 268 and 420, from Kosorz and Lochkov, in Czechoslovakia. In this species the grooves on the exterior surface of the shell are minutely and regularly pitted, each groove being occupied by a single vertical series of pits.

69. **Parakionoceras originale** (Barrande)

Orthoceras originale Barrande, Systeme Silurien du Centre de la Boheme, vol. 2, texte III, pl. 267, figs. 1–20 (1874).

Apical angle usually between 10 and 14 degrees, sometimes greater. The number of vertical lacunae within the circumference of the conch is about 60. The number of camerae in a length equal to the diameter of the conch appears to be about 3 where the diameter of the conch is 22 mm. At this point the diameter of the siphuncle is between 1.5 and 1.75 mm. The connecting rings are cylindrical, but at the septal necks the siphuncle is constricted distinctly. Both vertical and transverse striae may be detected under a magnifier in the grooves between the ridges, exposed after the outer part of the shell, and the matrix filling the lacunae has peeled off. These minute striae, however, are not to be compared with the conspicuous markings seen on many species of the *Kionoceras* group of conchs.

Locality and horizon.—Karlstein, Hinter-Kopanina, Lochkov, and Kosorz, in the vicinity of Prague, Czechoslovakia. Types in the National Museum at Prague. The horizon is Middle Silurian, and approximately equivalent to the Racine of America.

70. **Murrayoceras murrayi** (Billings)

Plate LXXV, fig. 5

Orthoceras murrayi Billings, Geol. Surv. Canada, Rep. Progress for 1853–56, published in 1857, 332. See also Foord, Catalogue of Foss. Ceph. British Museum, 1, 328, fig. 50 A, B, C (1888).

Murrayoceras murrayi Foerste, Jour. Sci. Lab. Denison Univ., 21, 312 (1926).

Specimen 170 mm. long, enlarging laterally from a diameter of 36 mm. to 47 mm. in this length, the corresponding dorso-ventral diameters being 27.5 mm. and 31 mm. Cross-section subtriangular, the ventral and dorso-lateral sides being sufficiently flattened to produce this outline. The number of camerae in

a length equal to the lateral diameter of the conch varies from 13 at the lower end of the specimen to 16 at its upper end. The sutures of the septa curve downward ventrally and dorsolaterally, producing lateral and dorsal saddles. The elevation of the dorsal saddles is about 2 mm. above that of the lateral ones. Where the lateral diameter of the conch is 40 mm., the center of the siphuncle is 5 mm. from the flattened ventral wall. The siphuncle is 6 mm. in diameter. Its inner wall is lined with a calcareous deposit 1 mm., or a little more, thick, leaving a central dark calcitic space about 4 mm. in diameter. The septal necks are scarcely half a millimeter long, their lower margins being directed downward or faintly outward. The connecting rings are thinner and curve concavely inward along the lower two-thirds of the length of the camera. The lower margin of these connecting rings appears to invaginate into the top of the septal neck beneath.

Locality and horizon.—St. Joseph's Island, in the northwestern part of Lake Huron; in the Black River formation. No. 26584, in the British Museum of Natural History.

Remarks.—Conchs with similar flattened ventral sides, and with the siphuncle ventrad in location occur in the genera *Tripleuroceras*, *Tripteroceras* and *Allumettoceras*, but in none of these genera do the connecting rings of the siphuncle curve concavely inward as in *Murrayoceras*. *Orthoceras semiplanatum* Whiteaves is not related to *Murrayoceras*, its siphuncle being located on the convex side of the conch.

OFFLEYOCERAS Gen. nov.

Genotype: *Orthoceras arcticum* Foord.

Conch slightly curved lengthwise, with circular cross-section. Sutures of septa almost directly transverse. Siphuncle ventrad of center of conch; septal necks apparently continuous with the connecting rings, the latter curving slightly outward at mid-length, and their lower margins invaginating into the tops of the septal necks beneath so as to produce a holochoanoidal appearance.

71. Offleyoceras arcticum (Foord)

Plate LXXV, fig. 4

Orthoceras arcticum Foord, Cat. Foss. Cephalopoda, British Museum, 1, 38, text figures 3 a–d (1888).

Monocyrtoceras (?) *arcticum* Foerste, Jour. Sci. Lab. Denison Univ., 23, 100, pl. 6, fig. 1 (1928).

Living chamber 110 mm. long, 80 mm. in diameter dorso-ventrally and 77 mm. laterally at its base. At mid-height of the chamber the corresponding diameters are 87 mm. and 82 mm., these dimensions being retained as far as the aperture. Convexity of ventral vertical outline of chamber 9 mm.; concavity of dorsal outline only 1 or 2 mm., chiefly at top and bottom of chamber. This concavity increases distinctly along the dorsal outline of the phragmacone in a manner similar to Foord's figure. The siphuncle is ventrad of the center as in the cross-section published by Foord. Septal necks about 2.5 mm. long. Connecting rings curving gently outward along mid-height of the camerae, and then inward along the lower parts of the camerae, so as to invaginate into the tops of the septal necks beneath, resulting in a holochoanoidal appearance.

Shell 1.5 mm. thick ventrally, but scarcely half a millimeter thick dorsally. Surface transversely banded; bands 5 in a length of 28 mm. along the lower part of the living chamber, changing to 5 in a length of 18 mm. along its upper part. Along the ventral side of the chamber they curve slightly downward, for a distance of about 3 mm. The upper margin of these bands curves distinctly outward, and transverse markings corresponding to the bands appear on the cast of the interior of the chamber as faint annulations. In addition to the bands the surface of the shell is crossed by obscure transverse lines. The cast of the interior of the conch is faintly ribbed in a vertical direction, 5 ribs occurring in a width of 25 mm.

Locality and horizon.—Offley Island, Kennedy Channel, Arctic America; in grey, granular, Silurian limestone of Niagaran age. No. 89169, British Museum of Natural History.

Remarks.—It is possible that there is some relationship

between *Offleyoceras arcticum* and *Orthoceras sulmenevense* Foerste, described from an unknown horizon on Sulmeneva Fjord on the western coast of Novaya Zemblya, as far as the structure of their siphuncles is concerned, but the latter is not known to be curved lengthwise. Another conch to be studied in the same connection is *Orthoceras scheii* Foerste, from the Middle Devonian of Østre Bergen, on Gaase-fjorden (East Castle on Goose-fjord), in southwestern Ellesmereland, but the latter is a much more rapidly enlarging conch, and straight instead of curved lengthwise. However, the ventrad side of the siphuncle has a structure which is strangely like that of a holochoanoidal conch, though toward the interior of the conch an ellipochoanoidal structure is indicated by the presence of septal necks, but no connecting rings. It is evident that the significance of these structures is not yet understood, the specimens at hand not being sufficiently well preserved to reveal all the details of structure desired.

PROBILLINGSITES Gen. nov.

Genotype: *Probillingsites welleri* Foerste.

The genus *Billingsites*, described by Hyatt, is typified by *Billingsites canadensis* (Billings) from the English Head and Vaureal members of the Richmond of Anticosti. In this species the sutures of all the septa included within the gerontic expansion of the conch tend to be closely approximated or even to be more or less united into a single line along the ventral half of the conch. Along the middle of the lateral sides these more or less united sutures curve rather sharply upward and in a ventral direction, at the same time separating from each other and reaching different elevations along the lateral and ventro-lateral sides of the conch. From these different elevations they curve more or less directly toward the dorsal side of the conch, crossing the latter in an approximately horizontal direction, thus forming conspicuous dorsal saddles. If the strong reversal in direction of the course of the sutures at the base of these specimens be taken as essential characteristics of the genus, then *Billingsites acutus* Foerste, *Billingsites anticostiensis* (Billings), *Billingsites newberryi* (Bil-

lings), and *Billingsites elongatus* Foerste, all from the Richmondian and overlying Gamachian of Anticosti, are congeneric The genus also is represented by *Billingsites costulatum* (Whiteaves) from the Red River formation of southern Manitoba. A form closely similar to *Billingsites anticostiensis*, but a little more elongated, occurs in the Ogontz division of the Stonington member of the Richmond on the peninsula east of Escanaba, Michigan. Other specimens, also related to *Billingsites anticostiensis* occur at the base of the Whitewater member of the Richmond in Ohio and in the adjoining part of Indiana.

Typical *Billingsites* is preceded by species essentially similar in structure, but without the strong reversal in curvature of the sutures of the septa at the base of the ovoid gerontic expansion of the conch. The oldest known species of this type appears to be the species here described as *Probillingsites welleri*, whose geological horizon is unknown, but is assumed to be the Galena, or possibly even lower. Another form only slightly different from *Probillingsites welleri* is the species described originally as *Billingsites williamsportensis* Foerste, from the Catheys member of the Trenton in western Tennessee. A later derivative is the species described as *Billingsites primus* Fritz, from the Upper Coburg member of the Utica group, east of Collingwood, Ontario, Canada. This type of conch did not die out with the appearance of typical *Billingsites*, but continued into the lower Richmond, as is shown by the presence of the species described as *Billingsites manitoulinensis* Foerste, from the Meaford member of the Richmond, along the eastern margin of Manitoulin island. For these four species, *Billingsites* welleri, B. williamsportensis, B. primus, and B. manitoulinensis, the generic name *Probillingsites* here is proposed, with *Probillingsites welleri* as the genotype.

72. **Probillingsites welleri** Sp. nov.

Plate LXXI, figs. 2 A, B

Specimen including only the oviform gerontic enlargement of the conch. It consists of the last 4 gerontic stages of the living chamber. It enlarges from a lateral diameter of 25 mm. at the

base to about 36 mm. at mid-height, and then narrows to about 30 mm. at the aperture. The corresponding dorso-ventral diameters are 22 mm. at the base, 31 mm. at mid-height, and approximately 23 mm. at the aperture. The concavity of the septum at its base is 6 mm.; its maximum concavity is located at the point where the septum is pierced by the siphuncle, this point being 5 or 6 mm. from the ventral outline of the conch, and therefore much closer to the ventral than to the dorsal outline. The suture of this septum rises at an angle of about 45 degrees with the horizontal from the ventral toward the dorsal side of the conch. The second suture is parallel to the first on all sides except the center, and there it diverges slightly in an upward direction. The third suture diverges still more distinctly along its ventral side, and the fourth has a slight upward flexure along the middle of its ventral course. The ventral and dorsal views present ovoid outlines, the lower part of the specimen being narrower. The ventral outline of the specimen has a radius of convex curvature of 32 mm., while the dorsal vertical outline is only slightly convex. The upper part of the specimen is faintly constricted ventrally and laterally a short distance below the aperture, suggesting that the interior of the shell was thickened here. The aperture is transversely elliptical, but its margin is not preserved.

Locality and horizon.—The label accompanying this specimen gives the locality as Chicago, Illinois, and the horizon as Niagaran. However, the lithological appearance is altogether different from that of the Niagaran of this locality, and some unknown person subsequently crossed out the word Niagaran, written in ink, and substituted in its place the word Galena, in lead pencil. The Galena is regarded also by the present writer as a more likely source of this specimen than the Niagaran, both on account of the lithological appearance of the rock, and on account of the close relationship of this specimen to *Probillingsites williamsportensis*, the latter being definitely known to be of Catheys age. It should be noted in this connection that in volume II of the Geological Survey of Wisconsin, under Chamberlin, on page 325, an undetermined species of *Ascoceras* or *Cryptoceras* is listed from the modified Galena of that state. At that time

the genus *Billingsites* had not been instituted, and species now referred to that genus were still referred to *Ascoceras*, the latter genus being given a broader significance than it bears today. It is the use of the alternative *Ascoceras* or *Cryptoceras* which casts doubt on the value of the term *Ascoceras* in this connection. Named in memory of Prof. Stuart Weller, who contributed so much to Silurian geology.

Remarks.—*Probillingsites welleri* is related to *Probillingsites williamsportensis* Foerste from the Catheys of western Tennessee. It differs in being more slender, both dorso-ventrally and laterally, compared with its height; its dorsal outline is more nearly straight; and the sutures of its septa diverge slightly along the middle of their ventral course.

73. **Probillingsites williamsportensis** Foerste

Plate LXXV, fig. 11

Billingsites williamsportensis Foerste, Jour. Sci. Lab. Denison Univ., 20, 217, pl. 35, figs. 2 A, B, C (1924).

The primitive nature of this species is indicated by the straight course of the sutures of its septa which rise in a dorsad direction. A dorso-ventral section through the center of the specimen here is figured, showing the little that can be learned from the type. The septa can not be followed as far as the dorsal surface of the conch. A calcitic wall, 1 mm. thick, intervenes, which may represent the original thickness of the wall along this part of the conch, but if that is the case then this wall was abnormally thick.

Locality and horizon.—Williamsport, Tennessee; in the Catheys formation.

74. **Ulrichoceras beloitense** Foerste

Plate LII, fig. 4

Ulrichoceras beloitense Foerste, Jour. Sci. Lab. Denison University, 23, 211, pl. 47, figs. 1 A-C (1928).

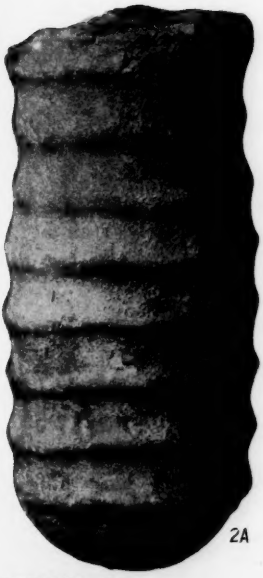
An illustration of the ventral side of the conch with its broad lobes in the sutures of the septa is here presented. Beloit, Wisconsin; in the Beloit member of the Black River. No. 25302, in the U. S. National Museum.

PLATES

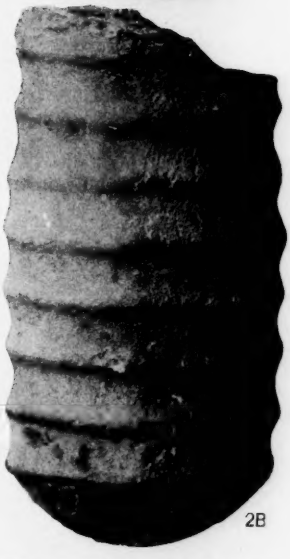
PLATE XLVIII

Fig. 1. *Elrodoceras* (?) *crebescens* (Hall). Figure including most of that part of the living chamber which remains in the specimen represented. Three millimeters above the suture at the base of this chamber there is a narrow groove, which was formed by the annular attachment ring on the inner surface of the shell surrounding the chamber. This ring rises in the form of an annular ridge and is found above the lower margin of the chamber in many cephalopods. The upper two camerae are distinctly shorter than those beneath, indicating that the conch had entered on its gerontic stage. Racine, Wisconsin; in the Racine dolomite. Type, No. 2107, American Museum of Natural History. Original of fig. 1, pl. 19, in 20th Rep. New York State Cab. Nat. Hist. (1868). See also pl. XLIX, fig. 2; LXXV, fig. 7.

Fig. 2. *Dawsonoceras hyatti* Foerste. Living chamber. A, lateral view. B, ventral view. Port Byron, Illinois; in the Port Byron member of the Niagaran. In the collection of Prof. T. E. Savage. See also plates LVIII and LIX.



2A



2B

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PLATE XLIX

Fig. 1. *Orthoceras subbaculum* Meek and Worthen. Only a part of the type here is represented, the entire phragmacone being 255 mm. long, and the living chamber 180 mm. long. Joliet, Illinois; in the Joliet member of the Niagaran. Type, No. 7771, Illinois State Museum of Natural History.

Fig. 2. *Elrodoceras* (?) *crebescens* (Hall). Specimen illuminated so as to emphasize the very faint broad transverse lines of growth. The very faint broad vertical markings figured by Hall (20th Rep. New York State Cab. Nat. Hist., pl. 19, fig. 3, 1868), are equally inconspicuous but are visible only when illuminated more directly from the side. Of these vertical markings there are 8 in a width of 20 mm. on the third camera above the base of the specimen. Original of fig. 3, on plate 19, cited above. Racine, Wisconsin; in the Racine dolomite. Paratype, No. 2107, American Museum of Natural History. See also plate XLVIII, fig. 1; LXXV, fig. 7.

Fig. 3. *Kionoceras fililineatum* Foerste. Fragment of a conch preserving the surface sufficiently well to show the primary vertical ribs, and 5 to 7 vertical striae on the spaces between the ribs. Bridgeport, Chicago, Illinois; in the Racine dolomite. No. 2282, Museum of Comparative Zoology, Harvard University. See also plate LXVIII, figs. 2, 1.

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PLATE L

Fig. 1. *Orthoceras whitfieldi* Foerste. A, lateral view. B, natural vertical section of same specimen, exposing the siphuncle. The length of the septal funnels is indicated. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. Type. In the Welch collection, Wilmington College.

Fig. 2. *Orthoceras whitfieldi* Foerste. Lateral view. Original of the specimen figured by Hall and Whitfield in Geol. Surv. Ohio, Pal. 2, pl. 9, fig. 2, under the name *Orthoceras crebescens*. Cedarville, Ohio; in the Cedarville dolomite. No. 3423, Ohio State University.

Fig. 3. *Orthoceras whitfieldi* Foerste. Natural vertical section, exposing the siphuncle. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

1A

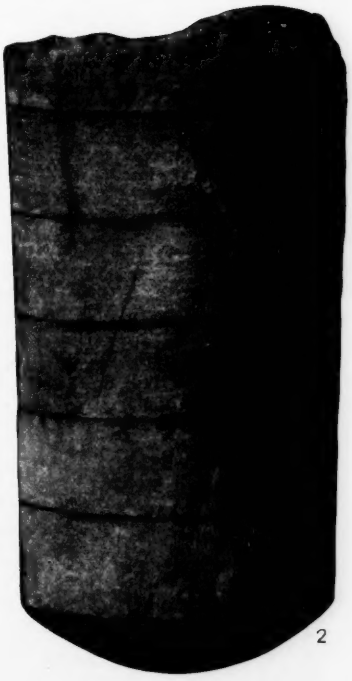

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PLATE LI

Fig. 1. *Orthoceras alienoides* Foerste. Living chamber, with trace of siphuncle at base. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

Fig. 2. *Orthoceras alienoides* Foerste. Upper part of phragmacone, with upper three camerae successively shorter, indicating gerontic conditions. Not definitely known to belong to same species as the living chamber here figured. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection, in the U. S. National Museum. See also plate LXXV, fig. 8.

Fig. 3. *Orthoceras byronense* Foerste. A, type, lateral view. B, specimen with a similar length of camera at top. Port Byron, Illinois; in Port Byron member of Niagaran. Nos. 447, 467 in Ward collection in U. S. National Museum.

Fig. 4. *Orthoceras alienum* Hall. Phragmacone, the upper part of which closely resembles fig. 7 on plate 24 of 20th Rep. New York State Cab. Nat. Hist., 1870, in structure, but not definitely known to belong to the same species as the living chamber represented by fig. 6 on the same plate, the latter being regarded as the type of the species. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 23105, Walker Museum, Chicago University. See also plate LXVII, fig. 4.

Fig. 5. *Orthoceras alienum* Hall. Specimen possibly belonging to the upper part of some phragmacone whose lower part more nearly resembled fig. 4 on this plate. In that case the relative length of the camerae increased toward the top of the phragmacone, at least previous to reaching gerontic conditions. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 21892, Walker Museum, Chicago University.

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3A

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PLATE LII

Fig. 1. *Orthoceras moodiense* Foerste. Phragmacone. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

Fig. 2. *Orthoceras shatzeri* Foerste. Phragmacone with base of living chamber still attached. Cedarville, Ohio; in the Cedarville dolomite.

Fig. 3. *Sactoceras* sp. Phragmacone. Cedarville, Ohio; in the Cedarville dolomite. No. 12 in text. See also plate LXXV, fig. 9.

Fig. 4. *Ulrichoceras beloitense* Foerste. Ventral view of endogastric conch, having sutures of septa with broad ventral lobes. Beloit, Wisconsin; in the Beloit member of the Black River. No. 25302 in the U. S. National Museum. See also Jour. Sci. Lab. Denison Univ., 23, plate XLVII, figs. 1 A, B, C, (1928).

Fig. 5. *Geisonoceras franklinense* (Miller). A, lateral view, with ventral outline on right. B, ventral view. Franklin county, Indiana; probably from the Laurel member of the Niagaran. No. 64336 in the U. S. National Museum.

Fig. 6. *Orthoceras penicillum* Foerste. Phragmacone, with upper camerae shorter than those beneath, indicating that the conch had entered on its gerontic stage. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College. See also plate LXXV, fig. 2.

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PLATE LIII

Fig. 1. *Geisonoceras rochesterense* Foerste. Lateral view, with ventral outline on the left. Large specimen, but only a part figured. Lockport, New York; in the Rochester shale. No. 10401, in the U. S. National Museum.

Fig. 2. *Geisonoceras wauwatosense* (Whitfield). A, living chamber, showing constriction along upper part of cast of interior of chamber. C, top of another chamber, also showing constriction of cast of interior. In A, the surface of the shell is minutely striated in a vertical direction. In B, these striae are more conspicuous. In C and D the transverse markings become more crowded toward the top. Wauwatosa, Wisconsin; in the Racine dolomite. No. 2303, Museum of Comparative Zoology, Harvard University.

Fig. 3. *Geisonoceras wauwatosense* (Whitfield). Chiefly a cast of the interior of a living chamber, with traces of the shell; also a small part of the siphuncle, Wauwatosa, Wisconsin; in the Racine dolomite. No. 611, in the Milwaukee Public Museum.


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2A


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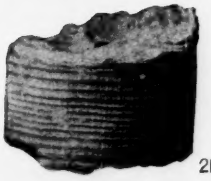
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2C


2D

PLATE LIV

Fig. 1. *Geisonoceras crebristriatum* (Meek and Worthen). Part of type specimen, the upper half of the living chamber, 110 mm. long, being omitted. Joliet, Illinois; in the Joliet member of the Niagaran, No. 2210, in the Illinois State Museum of Natural History, Springfield, Illinois.

Fig. 2. *Elrodoceras indianense* (Miller). Lateral view of phragmacone, with traces of sutures of septa along its right side. Joliet, Illinois; in the Joliet member of the Niagaran. No. 12105, in the museum of the University of Illinois. Original of the specimen figured by Meek and Worthen under the name *Orthoceras crebristriatum* (but not the type of that species), in Geol. Surv. Illinois, 6, pl. 26, fig. 2 (1875).

Fig. 3. *Cycloceras brucense* (Williams). Lateral view, with ventral outline on right, showing sutures of septa. Pine Tree harbor, Bruce peninsula, Ontario; in the Guelph formation. Same specimen as that figured in Geol. Surv. Canada, Memoir 111, pl. 27, fig. 1, but not the type. The latter is from Hay Bay, pl. 26, figs. 1 a, b, of paper cited.

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PLATE LV

Fig. 1. *Cycloceras jolietense* Foerste. Specimen retaining the basal part of the living chamber. The shortening of the upper two camerae indicates that the conch had entered on its gerontic stage. Faintly annulated. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22963, Walker Museum, Chicago University.

Fig. 2. *Cycloceras niagarense* (Hall). All but the basal part of the type specimen, with ventral side on left. Waukesha, Wisconsin; in the Waukesha dolomite, the next formation beneath the Racine. No. 2152, American Museum of Natural History.

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PLATE LVI

Fig. 1. *Cycloceras austini* Foerste. Lateral view with ventral outline on right. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection, in the U. S. National Museum. See also plate LXXV, fig. 6.

Fig. 2. *Cycloceras semotior* Foerste. Lateral view with ventral side on left. B is the basal part of A, and both together form only a part of the entire conch. The figures are only four-fifths of the natural size. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22961, Walker Museum, Chicago University.

Fig. 3. *Cycloceras junciforme* Foerste. Living chamber and the upper part of the phragmacone. The shortening of the upper camerae indicates that the conch was in its gerontic stage. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

Fig. 4. *Cycloceras junciforme* Foerste. Part of a body chamber, assumed to belong to the same species as the preceding specimen chiefly because it was found in the same quarry and at the same horizon. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection in the U. S. National Museum.

Fig. 5. *Leurocycloceras raymondi* Foerste. A, lateral view, with ventral outline on left. B, ventral side, showing tendency of annulations to become obsolete along its median part. Busack quarry, Wauwatosa, Wisconsin; in the Racine. No. 2306 a, Museum of Comparative Zoology, Harvard University.

Fig. 6. *Leurocycloceras wisconsinense* Foerste. Living chamber with weak annulations. Busack quarry, Wauwatosa, Wisconsin; in the Racine. No. 2306 c, Museum of Comparative Zoology, Harvard University.

Fig. 7. *Leurocycloceras wisconsinense* Foerste. Living chamber, showing the contraction of the cast of the interior at its upper end. Assumed to belong to the same species as the preceding on account of having similar weak annulations. Busack quarry, Wauwatosa, Wisconsin; in the Racine. No. 2306 b, Museum of Comparative Zoology, Harvard University.

Fig. 8. *Spyroceras crocus* (Billings). Living chamber with 6 camerae attached. Anticosti, probably from either the English Head or Vaureal formation. No. 2289, Museum of Comparative Zoology, Harvard University.

Fig. 9. *Geisonoceras wauwatosense* (Whitfield). Living chamber, in which the more prominent transverse striae frequently alternate with 2 striae, but occasionally also with 1 or 3. Wauwatosa, Wisconsin; in the Racine dolomite. No. 2303 C, Museum of Comparative Zoology, Harvard University. See also plate LXXV, fig. 13.

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PLATE LVII

Fig. 1. *Cycloceras niagarense* (Hall). Phragmacone with ventral outline on right. Annulations sloping slightly more than the sutures. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 7762, in the Illinois State Museum of Natural History, Springfield, Illinois. See also plate LXXV, fig. 10.

Fig. 2. *Cycloceras* sp. Fragment of a phragmacone, including one camera and most of another. Assumed to belong to the same species as fig. 6 on this plate. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 445 in the Ward collection in the U. S. National Museum. No. 32 in text.

Fig. 3. *Cycloceras semotior* Foerste. Lower part of living chamber and 6 camerae, with ventral outline on right. Possibly reaching maturity, the upper camerae being shorter than those beneath. Joliet, Illinois; in the Joliet member of the Niagaran. No. 2209, in the Illinois State Museum of Natural History, Springfield, Illinois. Type of the species.

Fig. 4. *Leurocycloceras raymondi* Foerste. A, ventral view; B, dorsal view; C, lateral view, with ventral outline on left. Wauwatosa, Wisconsin; in the Racine dolomite. No. 428 in the Ward collection in the U. S. National Museum.

Fig. 5. *Cycloceras brucense* (Williams). Vertical dorso-ventral section through the siphuncle of lower part of type specimen. See also Geol. Surv. Canada, memoir 111, pl. XXVI, figs. 1 a, b (1919).

Fig. 6. *Cycloceras* sp. Living chamber with one camera attached. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 444, in the Ward collection in the U. S. National Museum. No. 32 in text.

Fig. 7. *Cycloceras* sp. Fragment including one entire camera and part of two camerae. Assumed to belong to the same species as figs. 6 and 2 on this plate, because found at the same locality, but more distinctly annulated than the other two specimens. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 442, in the Ward collection, in the U. S. National Museum. No. 32 in text.


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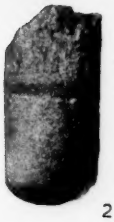
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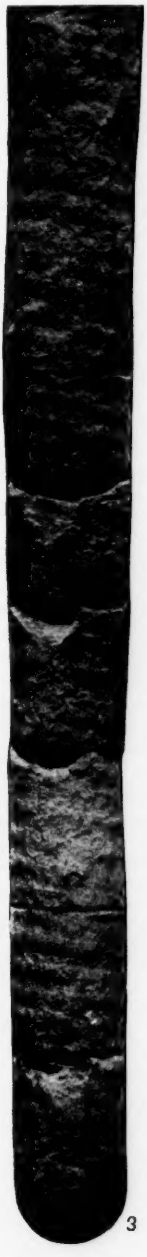
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4A


4B


4C


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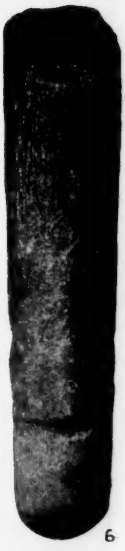
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PLATE LVIII

Fig. 1. *Dawsonoceras hyatti* Foerste. Ventral view, showing the broad lobes of the sutures and the similar downward curvature of the annulations. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College.

Fig. 2. *Dawsonoceras hyatti* Foerste. Conch imbedded in rock and exposing the siphuncle within three of its camerae. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College.

Fig. 3. *Dawsonoceras nodocostatum* (McChesney). A, exterior surface of conch; figure obtained by taking a plaster Paris cast of a natural impression of the outer surface of a shell in a slab of rock; showing both primary and secondary vertical ribs. B, transverse striae, rising more acutely where crossing the primary vertical ribs than where crossing the less conspicuous secondary vertical striae. Magnified 2 diameters. Quarry southwest of Springfield, Ohio; in the Cedarville dolomite. In the museum of Wittenburg College.

Fig. 4. *Dawsonoceras hyatti* Foerste. Ventral side of living chamber, showing the undulating transverse striae on the surface of the shell. Quarry southwest of Springfield, Ohio; in the Cedarville dolomite. In the museum of Wittenburg College. See also plate LXXV, fig. 3.

Fig. 5. *Dawsonoceras hyatti* Foerste. Vertical section of a conch exposing the siphuncle. Cedarville, Ohio; in the Cedarville dolomite.

Fig. 6. *Dawsonoceras graftonense* Foerste. Ventral view, showing downward curvature of the annulations along the median part of this side. Grafton, Illinois; in the Racine dolomite. No. 23107, Walker museum, Chicago University.

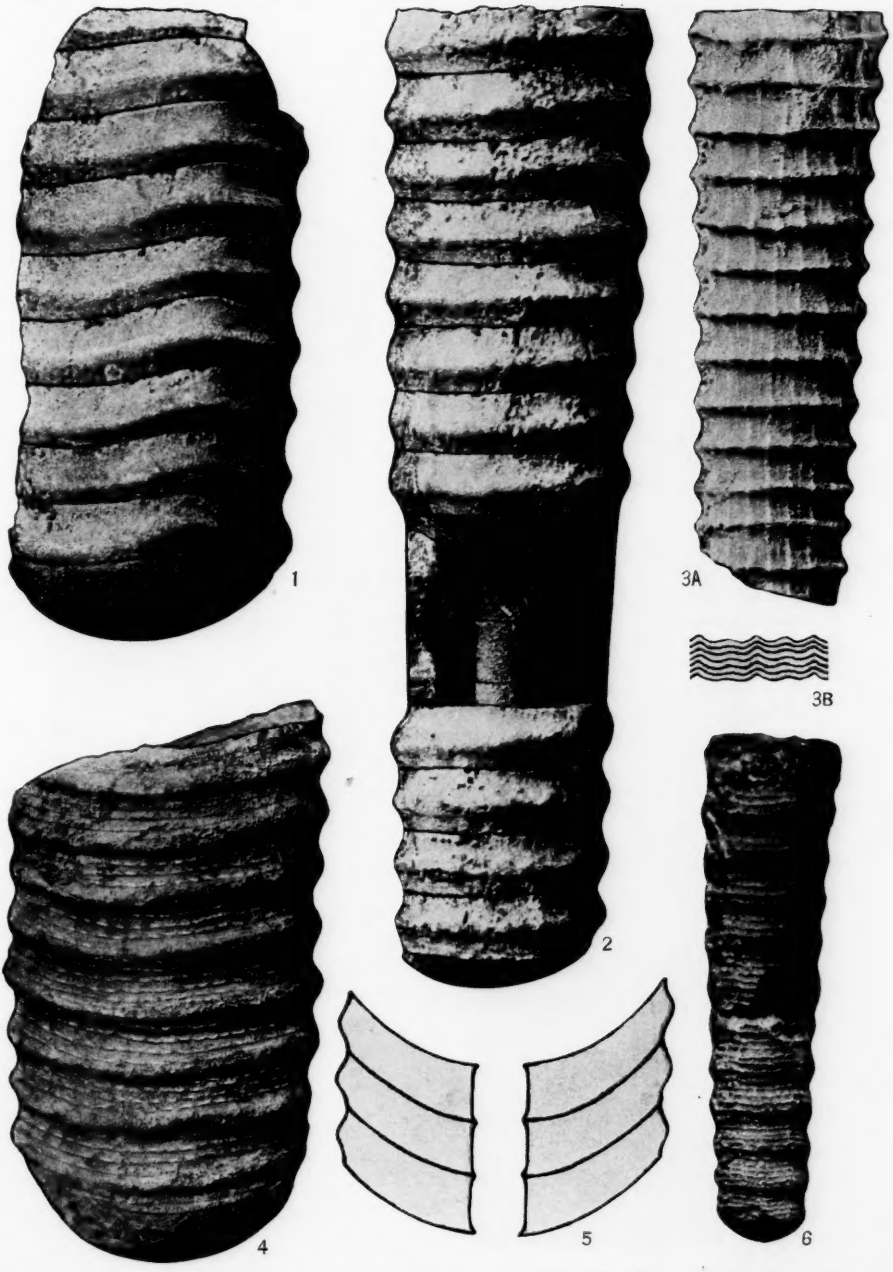

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PLATE LIX

Fig. 1. *Dawsonoceras nodocostatum* (McChesney). Surface of shell with vertical ribs which are more prominent where they cross the annulations. Also with transverse striae which curve slightly downward in the spaces between the vertical ribs. From the Racine dolomite of either Illinois or Wisconsin. In the U. S. National Museum.

Fig. 2. *Dawsonoceras hyatti* Foerste. Part of a conch 210 mm. long, showing the relatively numerous undulations along the transverse striae characteristic of this species. Joliet, Illinois; in the Joliet member of the Niagaran. No. 15001, Walker, Museum, Chicago University.

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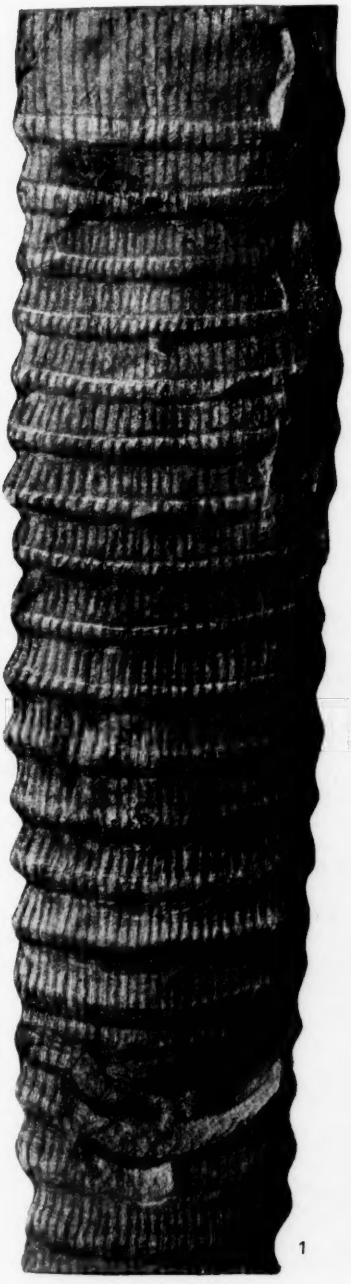
PLATE LX

Fig. 1. *Dawsonoceras multiliratum* Foerste. Part of a specimen 310 mm. long, with the vertical ribs very much accentuated by cross-illumination, so as to appear much more prominent than they really are. Wauwatosa, Wisconsin; in the Waukesha dolomite, directly beneath the Racine dolomite. No. 2311, Museum of Comparative Zoology, Harvard University.

Fig. 2. *Dawsonoceras multiliratum* Foerste. Specimen with vertical ribs very much accentuated by cross-illumination, so as to appear much more prominent than they really are. Joliet, Illinois; in the Joliet member of the Niagaran. No. 2310, Museum of Comparative Zoology, Harvard University. Type of this species.



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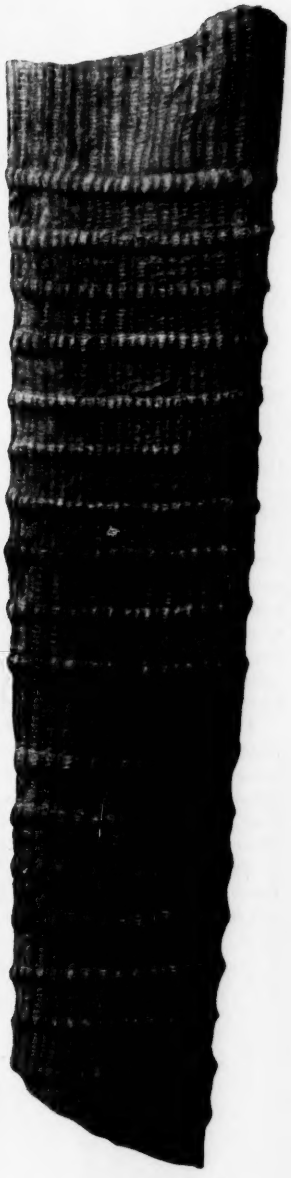

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PLATE LXI

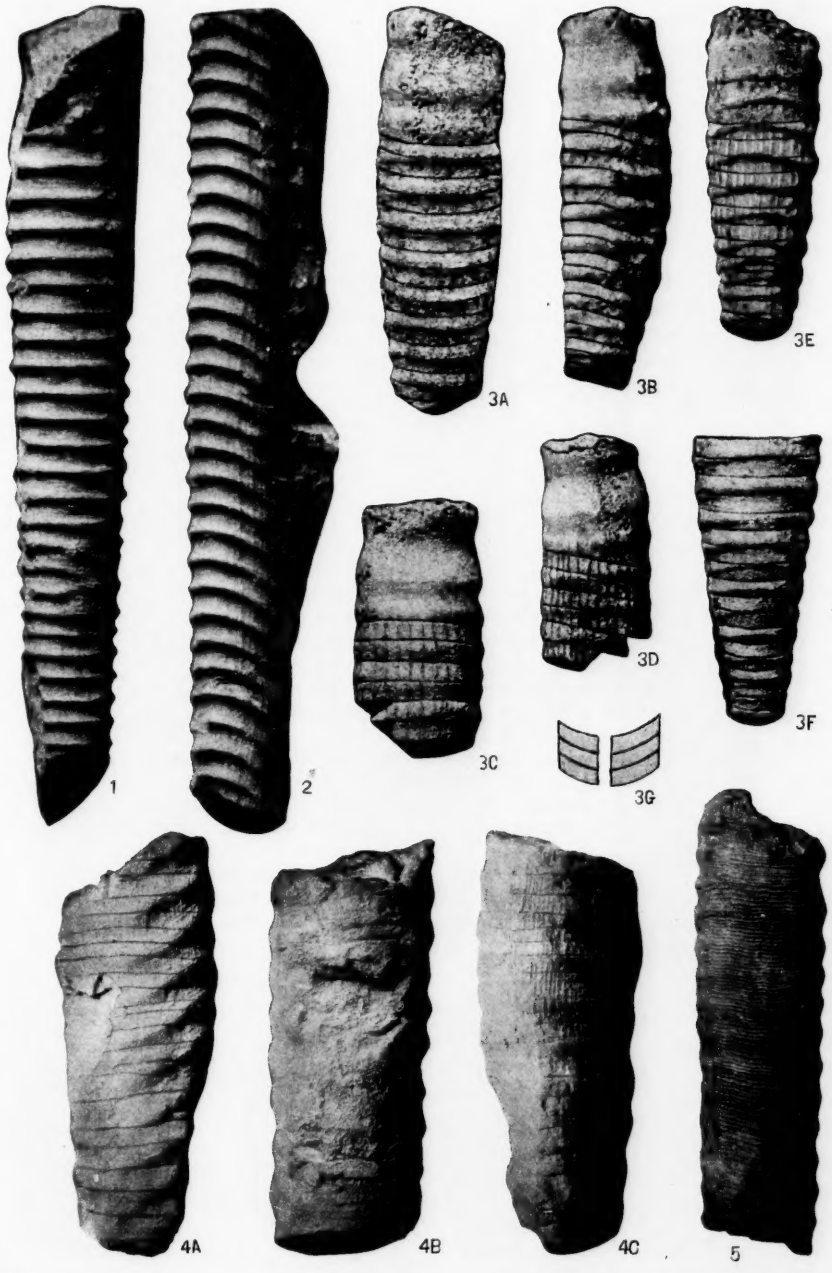
Fig. 1. *Dawsonoceras bridgeportense* Foerste. Specimen with somewhat sharply angular annulations. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 23104, Walker Museum, Chicago University.

Fig. 2. *Dawsonoceras bridgeportense* Foerste. Specimen with oblique annulations and with vertical ribs; the ventral side is on the right. Type of this species. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 23103, Walker Museum, Chicago University.

Fig. 3. *Spyroceras ruedemanni* Foerste. A, ventral view, showing annulations; these annulations tend to occur on alternate camerae along the median part of he ventral side of this specimen. B, lateral view of same specimen, with ventral side on right. C, dorsal side of another specimen, showing the annulations. D, lateral view of same specimen, showing the rise of the annulations in a ventrad direction. E, ventral side of another specimen, with the annulations rising in a ventrad direction. F, another phragmacone with the annulations rising ventrally. G, vertical section of specimen C, D, showing the siphuncle. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. Specimens A, B, F, in the Welch collection in Wilmington College. Specimen C, D, G, from the Austin collection in the U. S. National Museum. Specimen E, in Walker Museum, Chicago University.

Fig. 4. *Spyroceras gorbyi* (Miller). A, lateral view, with annulations sloping strongly downward in a ventrad direction. B, ventral view with the annulations becoming faint along the median part of this side. C, dorsal view, with the annulations rising on this side. Franklin county, Indiana; from the Richmond formation, probably from its Whitewater member. No. 64337, in the U. S. National Museum.

Fig. 5. *Dawsonoceras americanum* (Foord). Specimen showing the undulations of the transverse striae distinctly, but though distinct these undulations are relatively weak. Ripley county, Indiana; in the Osgood formation. In the U. S. National Museum.



AUG. F. FOERSTE

AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXII

Fig. 1. *Kionoceras scammoni* (McChesney). View of surface of the shell with its vertical ribs and prominent transverse striae; obtained by taking a cast of a natural impression of the exterior of a shell in a slab of rock. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 715 A, Walker Museum, Chicago University.

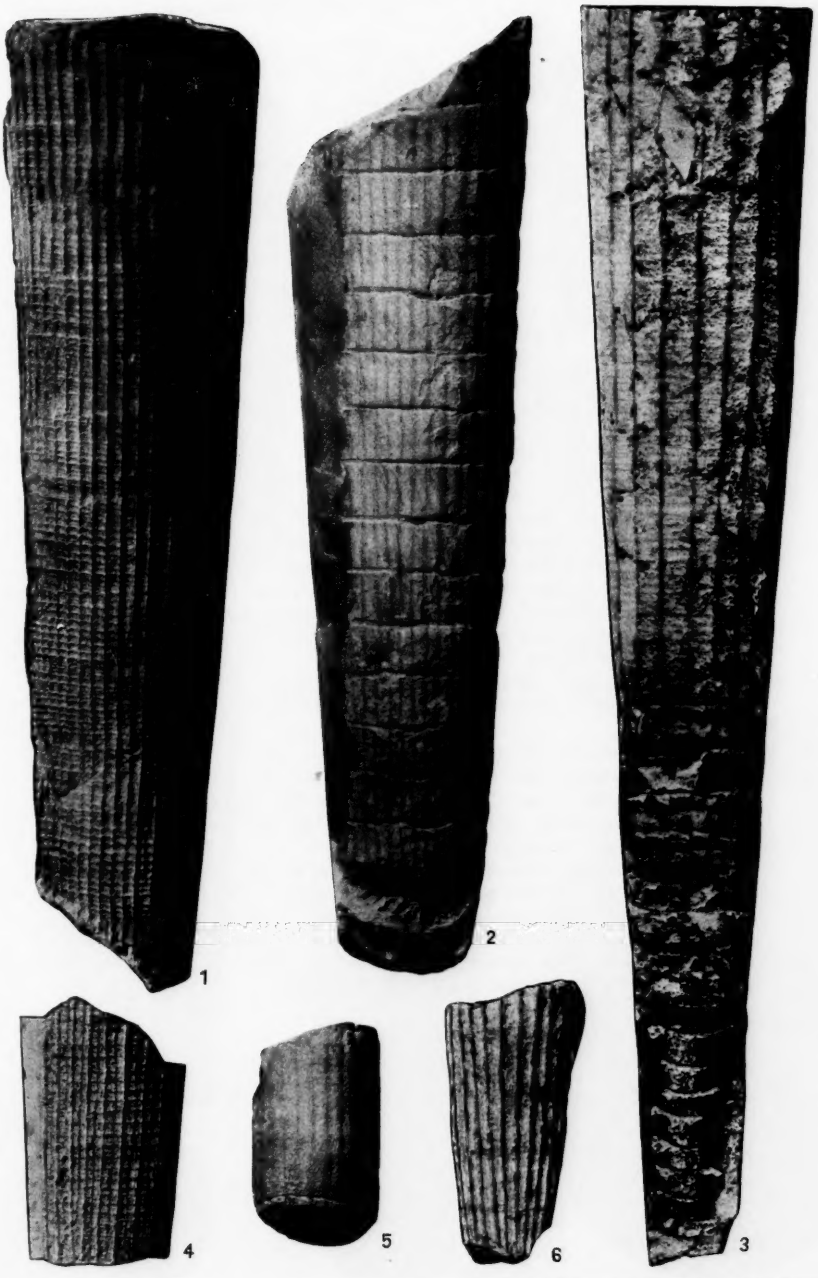
Fig. 2. *Kionoceras scammoni* (McChesney). Cast of interior of a phragmacone, without a trace of striae, either transverse or vertical. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 2297 A, Museum of Comparative Zoology, Harvard University.

Fig. 3. *Kionoceras loxias* (Hall). All but the extreme top of the type of this species, with distinct though weak traces of the transverse striae. The siphuncle and septa are exposed along the lower part of the phragmacone. Probably from the northwestern shore of Lake Michigan, on the peninsula extending southward from Manistique as far as Point Detour; in the Manistique member of the Niagaran. No. 2105, in the American Museum of Natural History.

Fig. 4. *Kionoceras* sp. Impression of exterior surface of shell of some species related to the *Kionoceras scammoni* group. Shelby, New York; in the Lower Shelby dolomite, a member of the Lockport formation. No. 12384–2, New York State Museum. No. 47 in text.

Fig. 5. *Kionoceras* sp. Living chamber, with a short camera still attached. The latter evidently is one of the shortened camerae formed in the gerontic stage of growth of a conch. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 439, in the Ward collection in the U. S. National Museum. No. 57 in text.

Fig. 6. *Kionoceras* sp. A rapidly expanding conch showing faint contractions at rhythmic intervals. Yellow Springs, Ohio; in the Cedarville dolomite. No. 3431 B, in the museum of Ohio State University. No. 46 in text.



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AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXIII

Fig. 1. *Kionoceras austini* Foerste. Phragmacone. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College. See also plate LXXV, fig. 15.

Fig. 2. *Kionoceras scammoni* (McChesney). Phragmacone, cast of interior of conch, with faint traces of transverse striae. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 2216, in the Illinois State Museum of Natural History.

Fig. 3. *Kionoceras myrice* (Hall and Whitfield). Living chamber and upper part of phragmacone. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College.

Fig. 4. *Kionoceras myrice* (Hall and Whitfield). Cast of interior of a conch, including the living chamber. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In Walker Museum, Chicago University.

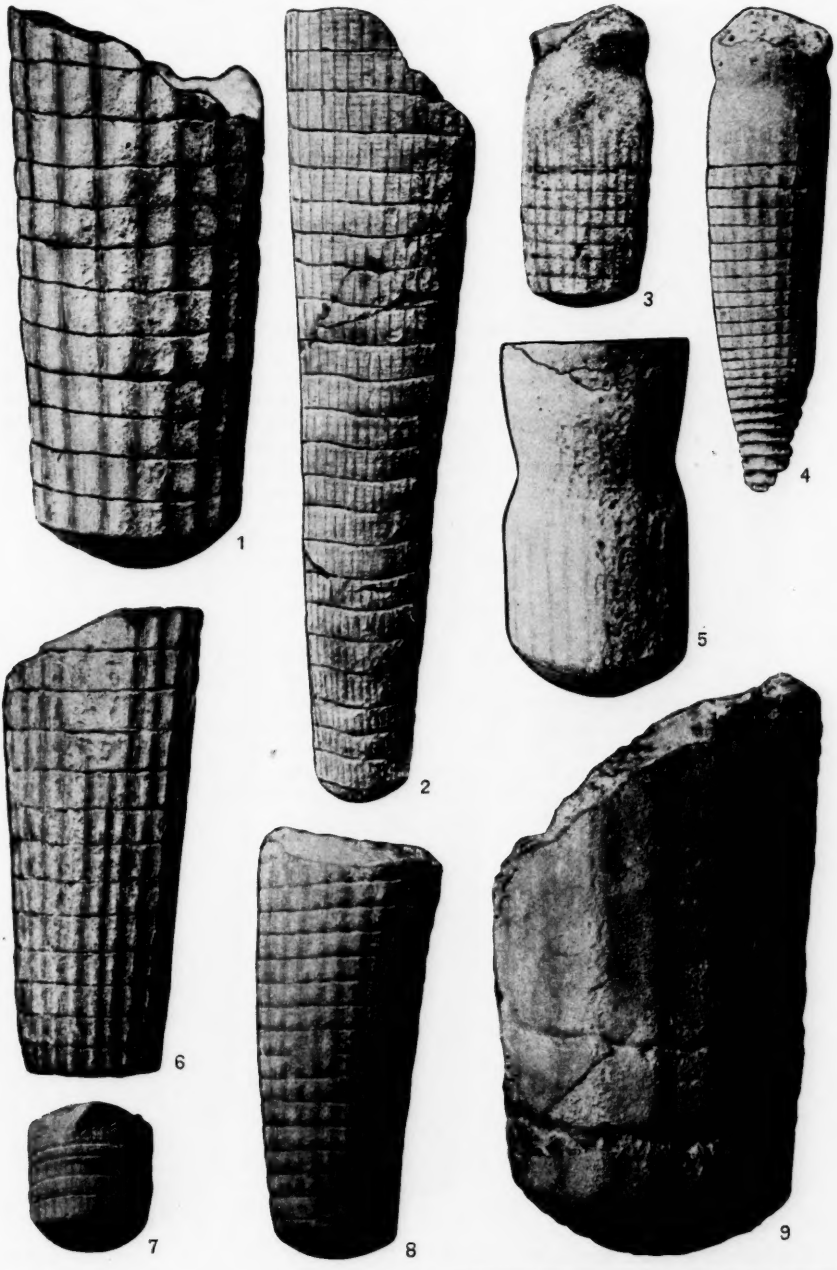
Fig. 5. *Kionoceras* sp. A living chamber with traces of 25 vertical ribs along its lower half. Apparently belonging to the *Kionoceras myrice* group, but differing from that species in its much larger size. Cedarville, Ohio; in the Cedarville dolomite. No. 66 in text.

Fig. 6. *Kionoceras austini* Foerste. Phragmacone. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College.

Fig. 7. *Spyroceras ruedemanni* Foerste. Basal part of living chamber and top of phragmacone. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 441, in the Ward collection in the U. S. National Museum.

Fig. 8. *Kionoceras* sp. Specimen with 29 vertical ribs. Similar to *Kionoceras myrice*, but larger; possibly belonging to same species as fig. 5 on this plate. Comparable also with *Kionoceras woodworthi* (McChesney), as far as size of conch and number of vertical ribs are concerned. Cedarville, Ohio; in the Cedarville dolomite. No. 9444, in the museum of Ohio State University. No. 48 in text.

Fig. 9. *Kionoceras* cf. *strix* (Hall and Whitfield). Lower part of living chamber and two camerae. Port Byron, Illinois; in the Port Byron member of the Niagaran. No. 189 in the collection of Prof. T. E. Savage.



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AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXIV

Fig. 1. *Kionoceras orus* (Hall). A, B, C, the specimens figured by Hall in 20th Rep. New York State Cab. Nat. Hist., on plate 19, in 1868, under the name *Orthoceras columnare,* later changed to *Orthoceras orus,* the former being preoccupied. Of the figures on the present plate, *A* corresponds to Hall's figure 4; *B* to his fig. 6; and *C* to his fig. 8. Of these figures *B* is selected here as the type of the species since it is the only specimen preserving any information regarding the character of the ornamentation of the surface of the shell. Racine, Wisconsin; in the Racine dolomite. No. 2106, American Museum of Natural History.

Fig. 2. *Kionoceras* sp. Surface of a shell which is faintly annulated at approximately rhythmic intervals. The original is an impression of the exterior of the shell in a fragment of dolomite, and the figure here presented is a plaster Paris cast of this impression. This cast shows 10 transverse striae in a length of 10 mm. Racine, Wisconsin; in the Racine dolomite. No. 2108 C, American Museum of Natural History. No. 46 of text.

Fig. 3. *Kionoceras scammoni* (McChesney). Surface of the shell with the characteristic vertical ribs and transverse striae of this species. The original is an impression of the surface of the shell in a fragment of rock. The figure was prepared from a plaster Paris cast of this impression. Racine, Wisconsin; in the Racine dolomite. No. 2108 B, American Museum of Natural History.

Fig. 4. *Kionoceras austini* Foerste. Phragmacone. Moodie Quarry, Wilmington, Ohio; in the Cedarville dolomite. Type. In the Austin collection in the U. S. National Museum.

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AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXV

Fig. 1. *Kionoceras mcchesneyi* Foerste. Phragmacone. The grooves between the vertical ribs are occupied by 11 to 16 very narrow vertical striae. Lennon, Waukesha county, Wisconsin; in the Waukesha dolomite, directly beneath the Racine dolomite. No. 4706, in the Public Museum of Milwaukee, Wisconsin.

Fig. 2. *Kionoceras mcchesneyi* Foerste. Phragmacone preserving the shell. The number of vertical striae in the grooves between the vertical ribs is about 7 or 8. Joliet, Illinois; in the Joliet member of the Niagaran. Type of this species. No. 18109, Walker Museum, Chicago University.

Fig. 3. *Kionoceras* sp. Fragment of a conch with relatively faint and narrow annulations at rhythmic intervals. Yellow Springs, Ohio, in the Cedarville dolomite. No. 3431 A, in the museum of Ohio State University. No. 46 of text.

Fig. 4. *Kionoceras scammoni* (McChesney). Original of the specimen figured by Hall under the name *Orthoceras angulatum*, in 20th Rep. New York State Cab. Nat. Hist. pl. 19, fig. 9, in 1868. The transverse striae are well indicated near the base of the specimen. Racine, Wisconsin; in the Racine dolomite. No. 2108, American Museum of Natural History.

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AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXVI

Fig. 1. *Kionoceras strix* (Hall and Whitfield). Specimen including most of the living chamber, and a considerable part of the phragmacone. The intervals between the vertical ribs are occupied by 7 or 8 vertical striae. From some part of the Niagaran of the Wabash valley in northern Indiana. No. 7304, in the U. S. National Museum.

Fig. 2. *Geisonoceras wortheni* Foerste. Specimen apparently consisting of a living chamber with 4 camerae attached, however, the sutures of the septa limiting these camerae are not very satisfactorily defined. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22962, Walker Museum, Chicago University.

1 2

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PLATE LXVII

Fig. 1. *Kionoceras strix* (Hall and Whitfield). Surface of specimen with about 7 vertical striae in the grooves between the vertical ribs, the alternate 3 of these striae being slightly more conspicuous than the remainder. Greene county, Ohio, probably at Cedarville; in the Cedarville dolomite. No. 3160, in the museum of Ohio State University.

Fig. 2. *Kionoceras scammoni* (McChesney). A, phragmacone. B, a second phragmacone with trace of siphuncle at base. There are faint traces of transverse striae. Bridgeport, Illinois; in the Racine dolomite. No. 7770, in the Illinois State Museum of Natural History.

Fig. 3. *Kionoceras crooki* Foerste. Phragmacone showing the vertical ribs, exposing the siphuncle at the top of the specimen. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22918 C, Walker Museum, Chicago University.

Fig. 4. *Orthoceras alienum* (Hall). Cast of interior of living chamber, constricted toward its top. Racine, Wisconsin; in the Racine dolomite. Selected as type of species. No. 2103, American Museum of Natural History. Same specimen as fig. 6 on pl. 24, in 20th Rep. New York State Cab. Nat. Hist., published in 1870.

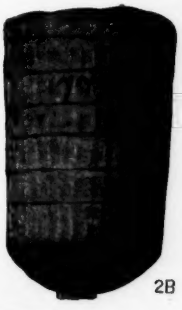
Fig. 5. *Kionoceras multiseptatum* Foerste. Living chamber and upper part of phragmacone, the cast of the living chamber being contracted near its top. Wauwatosa, Wisconsin; in the Waukesha member of the Niagaran, directly beneath the Racine dolomite. No. 621, in the Public Museum of Milwaukee, Wisconsin.

1

2A

3

4



2B

5

PLATE LXVIII

Fig. 1. *Kionoceras fililineatum* Foerste. Living chamber with sharply defined narrow vertical ribs. Bridgeport, Illinois; in the Racine dolomite. No. 2295, Museum of Comparative Zoology, Harvard University.

Fig. 2. *Kionoceras fililineatum* Foerste. Living chamber, with traces of 3 to 5 very fine vertical striae in the spaces between the narrow vertical ribs. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 25852 B; in the U. S. National Museum.

1 2

AUG. F. FOERSTE AMERICAN ORTHOCONIC SILURIAN CEPHALOPODS

PLATE LXIX

Fig. 1. *Protokionoceras meaullare* (Hall). Part of type specimen, omitting 3 camerae at top, and 2 fragments of camerae at the base. The vertical striae or ribs alternate moderately in size. The transverse striae are much less conspicuous. Waukesha, Wisconsin; in the Racine dolomite. No. 2102, American Museum of Natural History.

Fig. 2. *Protokionoceras crooki* Foerste. Cast of interior of conch, with more conspicuous transverse striae, and with more conspicuous alternation of primary and secondary vertical striae. Joliet, Illinois; from the Joliet member of the Niagaran. No. 7766, in the University of Illinois. Same specimen as that represented by fig. 1, on pl. 26, of Geol. Surv. Illinois, 6 (1875). See also plate LXXV, fig. 12.

1

2

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PLATE LXX

Fig. 1. *Protokionoceras* sp. Specimen with much finer vertical striae than in *Protokionoceras medullare*, also more closely crowded. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22969, Walker Museum, Chicago University. No. 66 in text.

Fig. 2. *Protokionoceras medullare* (Hall). Fragment of a conch showing the vertical striae or ribs on the surface of the shell. Bridgeport (Chicago), Illinois; in the Racine dolomite. No. 22910, Walker Museum, Chicago University.

Fig. 3. *Protokionoceras crooki* Foerste. A, with the striae on the surface of, the shell preserved fairly well. B, with the striae much better preserved. Joliet, Illinois; in the Joliet member of the Niagaran. No. 22918, Walker Museum, Chicago University.

Fig. 4. *Protokionoceras crooki* Foerste. Not distinguishable from the more typical representatives of this species in our present knowledge of the St. Clair specimens. A, B, C, three specimens, probably from different individuals, showing surface striae very well. St. Clair, Arkansas; in the St. Clair division of the Niagaran. No. 22942, Walker Museum, Chicago University.


1
2
3A
3B
4A
4B
4C

PLATE LXXI

Fig. 1. *Elrodoceras carmani* Foerste. Phragmacone weathered so as to show the siphuncle. Greene county, Ohio, probably from Cedarville; in the Cedarville dolomite. No. 1876, in the museum of Ohio State University.

Fig. 2. *Probillingsites welleri* Foerste. A, lateral view, with ventral outline on right, showing the sutures of 3 septa, the base of the specimen being formed by a fourth septum. B, ventral view of same. Probably either from the Galena of Illinois or Wisconsin. No. 4624, Walker Museum, Chicago University.

1A

2A

2B

PLATE LXXII

Fig. 1. *Elrodoceras abnorme* (Hall). Specimen exposing the siphuncle along its lower third; the latter with typical actinoceroid deposits within its interior. Racine, Wisconsin; in the Racine dolomite. No. 2109, American Museum of Natural History. Type figured by Hall in 20th Rep. New York State Cab. Nat. Hist., pl. 18, fig. 10, but with the upper 2 segments of that part of the siphuncle figured by Hall not exposed. That part of the conch which covers these 2 segments has been replaced in order to give a better idea of the curvature and rate of enlargement of the lower part of the conch. See also plate LXXV, fig. 1.

Fig. 2. *Elrodoceras* cf. *abnorme* (Hall). Lateral view of conch, showing the curvature along its ventral outline. Cedarville, Ohio; in the Cedarville dolomite.

Fig. 3. *Elrodoceras* cf. *abnorme* (Hall). A, two segments of the siphuncle, partly surrounded by the cystoid structure occupying the adjoining part of the interior of the camerae. B, the same, viewed from beneath. Cedarville, Ohio; in the Cedarville dolomite.

Fig. 4. *Elrodoceras* cf. *cedarvillense* Foerste. Apical end of a siphuncle, with vertical outlines of segments less convex than in typical *Elrodoceras abnorme*. Cedarville, Ohio; in the Cedarville dolomite.

Fig. 5. *Elrodoceras* cf. *abnorme* (Hall). Four segments of a siphuncle with the vertical outlines of these segments apparently more convex than those in fig. 4 of this plate. Quarry southwest of Springfield, Ohio; in the Cedarville dolomite. Museum of Wittenberg College.


5
4
2
3B
3A
1

PLATE LXXIII

Fig. 1. *Elrodoceras* sp. Phragmacone. Cedarville, Ohio; in the Cedarville dolomite. No. 23 of text.

Fig. 2. *Elrodoceras* sp. Phragmacone. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Welch collection in Wilmington College. No. 23 of text.

Fig. 3. *Orthoceras wilmingtonense* Foerste. Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite. In the Austin collection, in the U. S. National Museum.

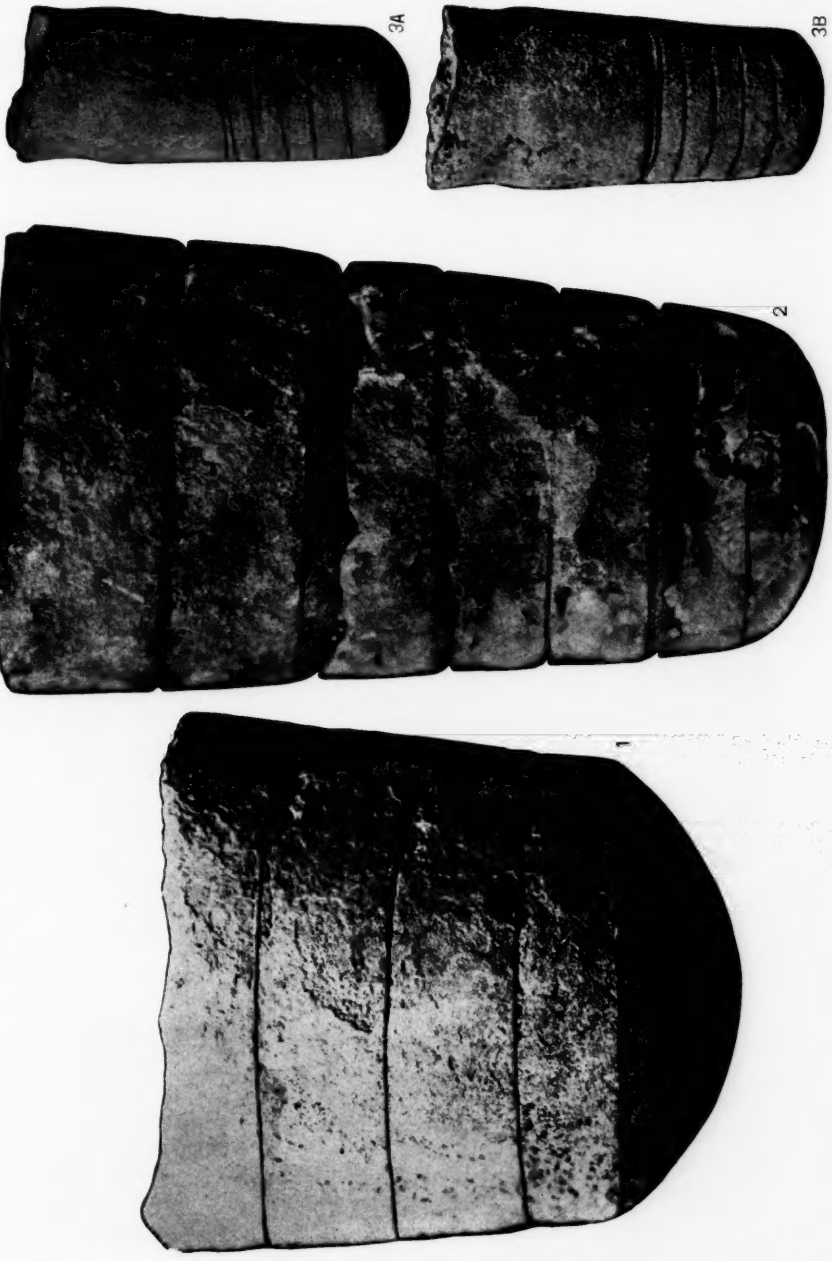
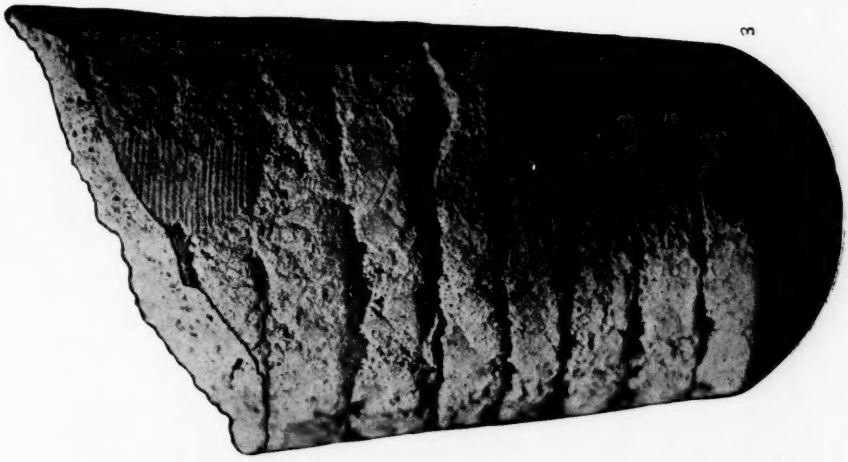

3A
3B
2
1

PLATE LXXIV

Fig. 1. *Orthoceras wilmingtonense* Foerste. A, dorsal view. B, cross-section of another specimen, that represented by figs. 3 A, B, on the preceding plate. Fig. 1 A is taken from a specimen in the Welch collection in Wilmington College. Fig. 1 B is from a specimen in the Austin collection in the U. S. National Museum. Both are from the Moodie quarry, Wilmington, Ohio; in the Cedarville dolomite.

Fig. 2. *Orthoceras* sp. Living chamber with 2 camerae attached. Cedarville, Ohio; in the Cedarville dolomite. No. 9 of text.

Fig. 3. *Elrodoceras cedarvillense* Foerste. Phragmacone, with a fragment of the shell preserved. Cedarville, Ohio; in the Cedarville dolomite.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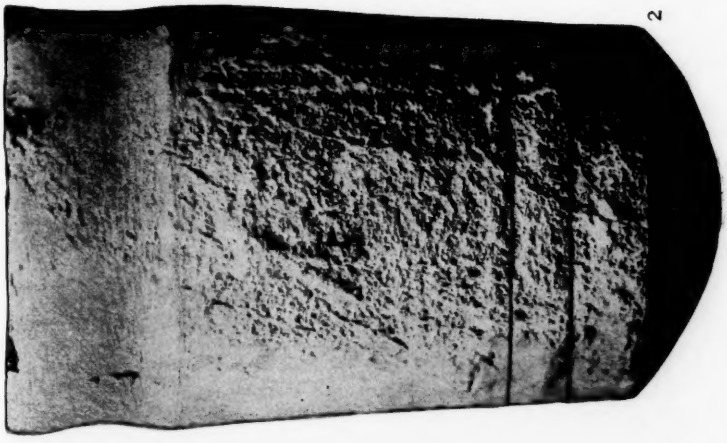

2


1A

1B

PLATE LXXV

Fig. 1. *Elrodoceras abnorme* (Hall). Dorso-ventral vertical section through the siphuncle. Figure prepared from type specimen illustrated by fig. 1 on plate LXXII.

Fig. 2. *Orthoceras penicillum* Foerste. Vertical section through conch, to show curvature of septa. See also fig. 6 on plate LII.

Fig. 3. *Dawsonoceras hyatti* Foerste. A small part of three undulating transverse striae, magnified 2 diameters. Drawn from striae occupying one of grooves between the annulations of specimen illustrated by figure 4 on plate LVIII.

Fig. 4. *Offleyoceras arcticum* (Foord). Dorso-ventral section through siphuncle of base of type specimen illustrated by fig. 1 on plate VI of this volume.

Fig. 5. *Murrayoceras murrayi* (Billings). Lateral section through the siphuncle of the specimen illustrated by Foord in Cat. of Foss. Cephalopoda in British Museum, 1, 328, figs. 50 A, B, C, (1888). Magnified 2 diameters.

Fig. 6. *Cycloceras austini* Foerste. Vertical section through siphuncle of specimen represented by figure 1 on plate LVI.

Fig. 7. *Elrodoceras* (?) *crebescens* (Hall). Vertical section through siphuncle, modified from fig. 2 on plate 19 of 20th Rep. New York State Cab. Nat. Hist., 1868. See also plate XLVIII, fig. 1, and plate XLIX, fig. 2.

Fig. 8. *Orthoceras alienoides* Foerste. Vertical section through siphuncle of specimen illustrated by figure 2 on plate LI.

Fig. 9. *Sactoceras* sp. (Cedarville, Ohio). Vertical section through siphuncle, showing septal necks whose lower margins curve outward. The connecting rings here drawn are but faintly and obscurely indicated in the actual specimen. Drawn from lower part of specimen illustrated by figure 3 on plate LII.

Fig. 10. *Cycloceras niagarense* (Hall). Vertical dorso-ventral section through siphuncle, prepared from basal part of specimen illustrated by figure 1 on plate LVII.

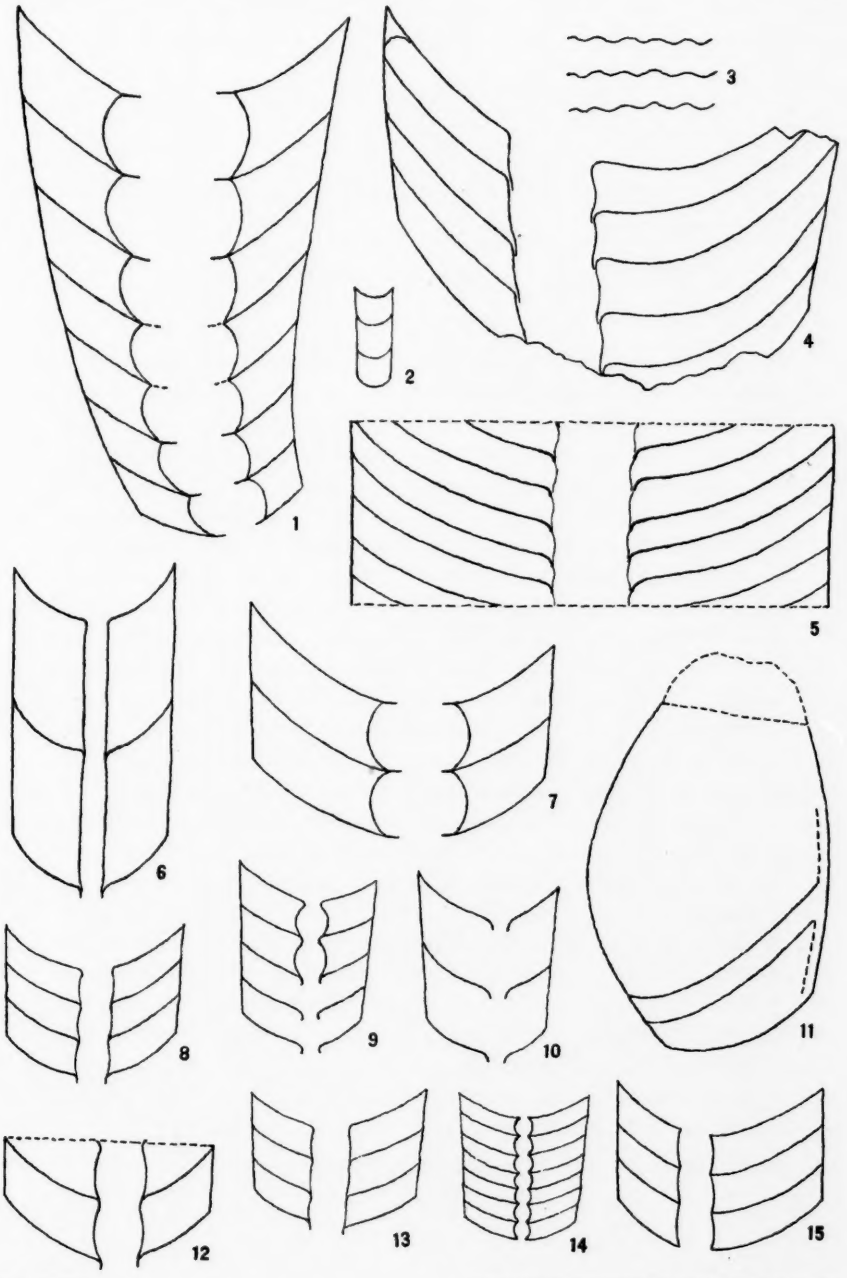
Fig. 11. *Probillingsites williamsportensis* Foerste. Vertical dorso-ventral section through center of conch, with dorsal outline on right, showing the last two septa produced by the animal. Taken from specimen illustrated by figures 2 A, B, C, on plate 35, of Jour. Sci. Lab. Denison Univ., 20 (1924).

Fig. 12. *Protokionoceras crooki* Foerste. Vertical section through the siphuncle, at top of specimen illustrated by figure 2 on plate LXIX.

Fig. 13. *Geisonoceras wauwatosense* (Whitfield). Vertical section through siphuncle of specimen No. 3169b in Milwaukee Public Museum. For other specimens see figures 2 A-D and 3 on plate LIII and also fig. 9 on plate LVI.

Fig. 14. *Kionoceras myrice* (Hall and Whitfield). Vertical section through siphuncle, showing moniliform siphuncle. Cedarville, Ohio. For illustration of typical form of this species see figure 4 on plate LXIII.

Fig. 15. *Kionoceras austini* Foerste. Vertical section through siphuncle with ventral side on left; same specimen as figure 1 on plate LXIII.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THE EROSIONAL HISTORY OF THE BLUE RIDGE

FRANK J. WRIGHT

Received November 13, 1928; published December 31, 1928

INTRODUCTION

In an earlier paper[1] the writer has stated briefly the problem of the Blue Ridge of the south, and outlined six theories of origin which have been set forth by various physiographers to account for this remarkable escarpment. The fault scarp theory was considered at some length, its implications cited, and the field evidence presented. The evidence was summarized and the conclusion reached that faulting has not been an important factor in the history of the Blue Ridge. In like manner it was proposed to consider each of the remaining five theories and try to find which one, if any, satisfies the conditions as they exist in the field. To this end a large part of the summer of 1927 was spent in western North Carolina during which time the territory from Blowing Rock to Lake Toxaway was traversed in a systematic manner. In earlier years the area from Roanoke to Blowing Rock had been studied, and this was again gone over in an effort to determine the unity of history of the entire region.

The author is especially indebted to Professor Douglas Johnson of Columbia University whose stimulating discussion of the Blue Ridge problem during a course of lectures at Columbia was responsible for the undertaking of the study. Many helpful suggestions as to procedure have been received from Professor Johnson. The field studies in 1927, as well as those in 1924, were made possible through a grant of money from the Esther Hermann Fund of The New York Academy of Sciences, and the writer desires to record his gratitude for this renewed appropriation.

In view of the fact that there has been some delay in preparing

[1] Frank J. Wright; The Blue Ridge of Southern Virginia and Western North Carolina; Jour. Sci. Labs. Denison Univ., 22, 116–132 (1927).

a more comprehensive report of the Blue Ridge, it seems wise to present tentatively the conclusions that have been reached in regard to the number and correlation of the erosion levels. It is hoped that this statement will be criticized, so that when the more complete story is written, the author may have the benefit of suggestions from those who have made physiographic studies in the Southern Appalachians.

It will be recalled that the Blue Ridge south of Roanoke, Virginia, is not a true ridge with two normal slopes, but rather a southeastward facing escarpment of 1500 to 2000 feet in height separating the Older Appalachians upland on the northwest from the Piedmont lowland on the southeast. This imposing feature rises steeply from the western margin of the Piedmont and marks the Atlantic-Mississippi divide throughout most of the way between Roanoke and northwestern Georgia. Davis[2] has written a very clear description of the escarpment and reviewed the work of Cobb and others.

THEORIES OF ORIGIN

The various theories which were stated in the article referred to at the beginning of this paper are these: (A) Fault Scarp Theory, (B) Marine Theory, (C) Theory of Warping, (D) Theory of Two Peneplanes of Different Ages, (E) Theory of Two Peneplanes of the Same Age, (F) Theory of Superior Rock Resistance.

A. Fault Scarp Theory

It was found that the topographic features which would be expected on the basis of a fault origin apparently do not exist. For that reason it is believed that faulting did not play an important part in the origin of the Blue Ridge.

B. Marine Theory

The marine interpretation, which makes the Blue Ridge a sea cliff and the Piedmont a wave-cut peneplane, has not been

[2] W. M. Davis; The Stream Contest along the Blue Ridge; Bul. Geog. Soc. Phila., 3, 213–244 (1903).

seriously proposed for the southern area so far as the writer is aware. However, in view of the importance attached to wave erosion, by certain authors, in the New England and Middle Atlantic states, it would certainly be wise to consider marine action as a possible factor in developing the Piedmont. A number of localities in the Piedmont, as well as sections of the Blue Ridge scarp itself, have been studied with the marine theory specifically in mind. These data are reserved for a later presentation. It may be said, however, that the weight of evidence is against marine origin.

C. Theory of Warping

The idea of warping or differential uplift has been advanced to explain the Blue Ridge escarpment. The Piedmont peneplane and the summit peneplane of the Blue Ridge are thus interpreted as parts of the same erosional surface separated by a steep upwarp which has been carved by streams into the present Blue Ridge. It is true, as will appear later, that Hayes and Campbell did not correlate the Piedmont peneplane with that found along the Blue Ridge crest. They did not recognize the Blue Ridge summit peneplane. In their interpretation the Piedmont and the Asheville are parts of the same deformed peneplane of Cretaceous age. Nevertheless, there has been some tendency to extend the idea of warping so as to make the *top* of the Blue Ridge an upwarped part of the same surface which forms the Piedmont on the southeast.

One of the outstanding contributions to the physiography of the Southern Appalachians was made by Hayes and Campbell.[3] They classified the topographic features of the region as follows:

> "1. Elevations standing above the Cretaceous peneplain.
> 2. Deformed Cretaceous peneplain.
> 3. Intermediate erosion slopes.
> 4. Deformed Tertiary peneplain.
> 5. Post-Tertiary erosion slopes."

[3] C. Willard Hayes and Marius R. Campbell; Geomorphology of the Southern Appalachians; National Geog. Magazine, 6, 63–126 (1894).

The Asheville level is treated as a representative of the Cretaceous peneplane.

"This type . . . . consists almost wholly of baseleveled valleys. They prevail from the vicinity of Roanoke, Virginia, to Cartersville, Georgia, giving rise to some prairie-like country in the heart of the Smoky mountains. It was in these valleys that this peneplain was first recognized. In a paper read before this Society in 1889 Willis described the baseleveled valley of the French Broad river . . . . "

In like manner the basin of the Catawba River, east of the Blue Ridge, was considered by Hayes and Campbell as probably representing the Cretaceous peneplane. Thus they say,

"It may be inferred that the valley of the Catawba river has been baseleveled to about the same extent as the French Broad at Asheville, and that the plain has been nearly as well preserved. Its altitude here is 1400 feet, so that it must have a very rapid ascent toward the west in order to reach an altitude of 2400 or 2500 feet at Asheville, which is only fifty miles distant. This sharp ascent of the Cretaceous peneplain on the eastern slope of the Blue Ridge dies out rapidly southward, partly through the flattening out of the fold in that direction and partly through the influence of a cross-axis of depression in the vicinity of Atlanta."

A third type of Cretaceous remnant is found in the southern portion of the Older Appalachians and is described as follows:

"In the region southwest from Atlanta as far as the Coosa river the present attitude of the peneplain differs from that in any other portion of the province. In this region the baseleveled plain has suffered but little uplift from the position in which it was formed, and this slight elevation has taken place in very recent geologic time. Hence the peneplain is well preserved and many of the present streams, as the Tallapoosa and its tributaries, are flowing partly on this old surface and partly in channels which they have been able to sink but a short distance below it, although it now stands from 1000 to 1400 feet above sealevel."

It will be noted that none of the Cretaceous peneplane remnants just described stand above 2400 feet. The "Map of the Southern Appalachians showing the deformed Cretaceous Peneplain," which appears as Plate 5, records no elevation above 2600 feet south of Asheville. The Asheville at 2400, the Catawba basin at 1400 and the Tallapoosa area at 1000 to 1400 feet represent the range in elevation.

The Tertiary peneplane, according to these writers, is preserved in the Appalachian Valley and in the marginal areas

surrounding the mountains of the Older Appalachians. The former is demonstrated especially well in the Shenandoah Valley in Virginia as well as in the basin of the New River and other streams farther south. With reference to the second type the authors say,

"On the southeastern margin of the province, throughout the Piedmont plain, the Tertiary peneplain is well developed and only occasional monadnocks show the position of the Cretaceous plain. Although crystalline rocks are generally regarded as offering great resistance to erosion, they are, under baseleveling conditions, subject to very deep decay and probably at the close of the Cretaceous cycle were softened to a far greater depth than at the present time. As the elevation succeeding the Cretaceous period of baseleveling was not great, the streams quickly swept away this mantle of residual material down to baselevel. Under such conditions the Tertiary peneplain was very perfectly developed throughout the whole of the Piedmont plain."

Great importance is attached to the deformation of the two peneplanes described in this paper. The deformation is assigned to

"true orogenic movements affecting comparatively narrow areas along certain well defined axes; that they were not epeirogenic or continental uplifts such as would preserve a peneplain in approximately its original horizontal position; . . . . "

Deformation along a series of longitudinal and transverse axes, is primarily responsible for the differences in elevation of the remnants of the Cretaceous peneplane. The movements which affected this peneplane include not only those associated with the uplift of the area inaugurating the second cycle, but also those connected with the uplift marking the close of the Tertiary cycle. The Tertiary surface has been modified by the later movements only.

In discussing the interrelations of the two peneplanes the authors make the following statements:

"In the vicinity of Atlanta the two baselevels are so near the same altitude that their peneplains cannot be discriminated, and the same is true along a line toward the northeast as far as Asheville. In the upper portion of the French Broad basin only one peneplain can be detected and it is ascribed to Cretaceous time."

The Cretaceous and Tertiary surfaces are thus believed to intersect in the western portion of the Piedmont. The Catawba

River basin is interpreted as the eastern portion of the Cretaceous surface which is upwarped toward the west to become the Asheville peneplane.

This idea developed by Hayes and Campbell as well as others, including Davis and McGee, has been widely accepted in the study of erosional surfaces. It is probable that all of the peneplanes of the Appalachian states have been uplifted as warped and domed surfaces. The fact that the elevation of the Upland peneplane ranges from 3000 to 4000 feet within the area under consideration is quite difficult to explain on any basis other than that of differential uplift. A feature like the Blue Ridge, however, would seem to require a sharp localized movement along an axis, akin to a monoclinal flexure. It would be interesting to determine, therefore, whether such a movement has been responsible for the disparity in elevation between the Catawba and Asheville basins as the authors suggested. The writer has searched for evidence bearing on the validity of this theory and will set down briefly his observations.

IMPLICATIONS OF THE THEORY

Assuming that the present Blue Ridge has been dissected out of an upwarped zone we should expect to find remnants of this steeply inclined surface in the form of long, tapering spurs leading from the Piedmont surface up toward the present scarp. It is well established by earlier writers that the Blue Ridge is a retreating divide. The vigorous eastward flowing streams have been, and still are, gaining territory from the more leisurely westerly flowing streams which have a greater distance to the sea. These spurs in their most characteristic preservation might be expected to present crestlines that are convex upward. Where dissection has broken the continuity of the spur the crests of the lower parts should have such angles of inclination that, if continued upward, they would attain the level of the summit at some imaginary point in front of the scarp. The spurs would in time disappear, and if the warping is assigned an early date perhaps all traces of them have been obliterated.

The second condition demanded by the theory is the presence of

a steeper slope of the peneplane along the western margin of Piedmont, showing the influence of upwarping in this area. It is inconceivable that the deformation should be restricted entirely to the zone of the scarp. The Piedmont surface should rise appreciably toward the base of the Blue Ridge and continue upward in tapering spurs toward its crest. This ideal preservation could be expected in only the most favored positions.

In the third place the theory makes the two peneplanes, separated by approximately 1500 feet in elevation, of the same age, being parts of the same surface formed under similar conditions. This would mean that they ought to show somewhat the same degree of development.

FIELD EVIDENCE

The Spurs. Almost every part of the scarp within the area under consideration was examined with reference to the nature and slopes of the spurs. At some places there appear to be spurs that support the warping theory, but in the majority of cases they do not. A few examples of each will be cited.

The road from Mt. Airy, North Carolina, to Hillsville, Virginia, traverses the western margin of Piedmont, ascends the Blue Ridge where it is very typically developed, and then passes down the gently sloping upland surface to Hillsville. At many points along the highway good views of the scarp may be had. Most of these do not show long spurs running up from Piedmont, but several do. A photograph is reproduced in plate LXXVI which shows, in addition to the long spur in the distance, a number of short steep spurs in the middle ground.

One of the most typical of the localities where the Blue Ridge has an abrupt southeastern slope with short, steep spurs is on the Hillsville quadrangle south of Fisher Peak, several miles east of Low Gap postoffice. A photo looking northeast along the base of the scarp at this point is shown in plate LXXVII.

The Blue Ridge scarp is much more dissected and the spurs are, therefore, more numerous as we go toward the southwest. A veritable maze of spurs and ridges running in many directions is seen east of Deep Gap west of Wilkesboro. The same is true

around the base of Grandfather Mountain and at scores of other localities farther south.

At several points where long spurs were observed, as near Piper Gap (Hillsville quadrangle), they were found to have crestlines that were not convincing. The slope of the lower part of the crest, if continued upward, would strike the present scarp below its summit. As pointed out in an earlier paragraph, such spurs cannot be regarded as supporting the theory. Their continuations should reach the level of the summit at an imaginary point in front of the present scarp, which has been driven back by erosion.

The spurs are in general neither straight nor parallel. They do not normally exhibit slopes that are convex upward. Frequently they are sprawling, and sometimes almost radial, as observed from promontories along the main scarp. Furthermore, Brushy Mountain and South Mountain, long ridgelike monadnocks closely associated with the Blue Ridge, but still detached from it, are not easily accounted for on this theory. They are so close to the scarp that they would probably belong, at least in part, to the upwarped zone, and yet cannot be interpreted as erosional features carved out of it.

In the southern part of the Hillsville quadrangle there are coves along the base of the Blue Ridge in which there are arms or extensions of the Piedmont surface between spurs of the escarpment. Near Hawk's Mill, for example, the peneplane is strikingly developed for over a mile between the ends of spurs on both sides. This evidence is clearly against the theory, and it appears often enough throughout the area to constitute a serious objection. The only apparent escape is to regard the extreme western margin of the Piedmont as a younger peneplane intersecting at a low angle the older peneplane at a very short distance east of the scarp. It is highly improbable that the face of the Blue Ridge has been dissected out of a steeply uparched erosion surface which was once the normal westward continuation of the Piedmont peneplane.

Relation of Piedmont Surface to Scarp. At no point did the writer observe any unusual upward rise of the Piedmont near the

base of the Blue Ridge. It usually steepens slightly as would be expected, due to the increased gradients of the streams, but not more so. The Piedmont juts right into the base of the escarpment. This relationship is well shown in the photograph reproduced in plate LXXVIII.

From the Winston-Salem-Mt. Airy highway about six miles east of Mt. Airy, North Carolina, one sees a grand sweep of the Piedmont surface rising gently northwestward, but cutting into the base of the Blue Ridge. The range of view is at least twenty miles. A more detailed view is secured from the highway about six miles north of Mt. Airy as one looks toward the northeast.

At several points between Roanoke and Afton, Virginia, north of this area, the writer has observed the same relationships. Between Bedford City and Lynchburg, west of Lynchburg, and a few miles south of Afton, the Piedmont surface juts into the base of the Blue Ridge. It does not rise abnormally along its western margin.

The Piedmont and Summit (Upland) peneplanes compared. Under the warping theory these two surfaces are parts of one extensive peneplane formed under rather uniform conditions. In view of similar rock types in the two regions the perfection of the erosion surface ought to be approximately the same throughout its parts. Let us examine two of the areas where the Upland peneplane is best developed.

Along the scarp near Fancy Gap, on the Hillsville quadrangle, we find one of the smoothest remnants of the Upland level. Even here the surface is not as perfect as the Piedmont. The hills are higher and the valleys deeper, the skyline less perfect and low monadnocks more numerous. The difference cannot be due to deeper dissection alone, for the valleys have a fairly mature aspect and the slopes are well graded. It does not look like the same surface warped to a higher level, but a different thing.

The summit peneplane is remarkably well preserved in the Caesar's Head, South Carolina, area as described by Keith in Folio 147, U. S. Geological Survey. Here again it is more uneven than Piedmont and also more dissected. In many localities between these points the higher peneplane is so much broken up

by the presence of monadnock masses, such as the Black Mountain group, that it is very difficult to find traces of it on the map or in the field.

There are some old, deeply decayed stream gravels along the crest of the Blue Ridge on the Hillsville quadrangle. They have been described by the writer.[4] Many of these gravels have been broken since rounding and hence at the present time they may show rounding only on parts of their surfaces. Gravels on the Piedmont hills are much more perfectly rounded. Sometimes they show pitting, for they, too, have suffered from weathering since rounding. But they are not so much broken and decayed, and clearly indicate younger age.

The writer is convinced that the Piedmont and Upland peneplanes represent different cycles of erosion.

Quite apart from the evidence furnished by the scarp and the adjacent Upland and lowland peneplanes, there is a suggestion in connection with the gradients of the local peneplanes. The Asheville surface is the best developed of a group of high-lying levels distributed throughout the mountain region. All of these surfaces slope gently upstream. The erosion surface developed by the New River slopes upward toward the south and southwest; the French Broad slopes in the same direction. The Swannanoa, a large tributary entering the French Broad at Asheville, has developed a baselevel which slopes upward toward the east. As one travels from Asheville toward Canton, he follows the beautifully developed Asheville level along Hominy Creek as it rises gradually to the Buncombe County line, a dozen miles away from Asheville. Five miles farther west, at Canton, the Pigeon River level stands at 2800 feet and it slopes downstream to the southwest, exactly opposite to that of Hominy Creek. The Piedmont slopes to the east and southeast. In view of the fact that these surfaces slope in almost all directions, it is quite obvious that some factor in addition to warping must be invoked to account for the disparity in elevation and direction of slope among the members of the group.

[4] Frank J. Wright; Gravels of the Blue Ridge; Jour. Sci. Labs. Denison Univ., 22, 133–135 (1927).

If it can be demonstrated that the Asheville and Piedmont peneplanes were developed in the second (Tertiary?), rather than in the first (Cretaceous?), cycle, as claimed by Hayes and Campbell, the origin of the Blue Ridge by warping would be less probable, because the lower peneplane experienced only the second deformation. The writer will attempt to show in a later paragraph that both levels really do belong to a single cycle more recent than the Cretaceous.

The field evidence would seem to indicate that while warping has had a part in the history of the Blue Ridge area, it was not primarily responsible for the scarp.

D. Theory of two peneplanes

The proponents of this theory hold that the Blue Ridge summit and Piedmont peneplanes were developed during different cycles of erosion. As early as 1889 Willis[5] presented a very illuminating description of the Asheville erosion surface and an outline of the physiographic history of the region. In the opening paragraph we get this picture of the peneplane.

"A broad amphitheatre lies in the heart of the North Carolina mountains which form its encircling walls; its length is forty miles from north to south and its width ten to twenty miles. At its southern gate the French Broad river enters; through the northern gate the same river flows out, augmented by the many streams of its extensive watershed."

His conclusions with regard to the erosional history of the Southern Appalachians are stated in the following quotation:

"2d. The balds of the Unakas represent the heights of that first-known approach to a baselevel."

"3d. The topography of the region has been revived by a general, though not necessarily uniform, uplift of 3000 feet or more, divided by two intervals of rest; during the first of these the Asheville baselevel was formed; during the second, the valley alone was reduced."

"4th. The latest movement of the uplift has been, geologically speaking, quite recent, and the revived streams have accomplished but a small part of their new task."

Peneplanes are thus represented by the balds of the Unakas, the Asheville level, and the floor of the Appalachian Valley. No

[5] Bailey Willis; Round about Nashville; National Geog. Magazine, 1, 291–300 (1889).

special attempt is made to account for the Blue Ridge escarpment. The above contribution is important, however, because of the light it sheds upon the history of the region.

Three peneplanes are also recognized by Keith.[6] In this publication appears his well-known panorama picture showing the Piedmont, the Blue Ridge scarp, and the Upland peneplane as they appear at Caesar's Head, South Carolina. He describes the three erosion levels in the following terms;

"These plateaus are alike in origin and form, but they vary considerably in altitude. They rise gradually toward the heads of the rivers and each major stream has its set of plateau altitudes. The plateau of Pigeon River near Waynesville and Sonoma is between 2700 and 2800 feet above sea; that of French Broad River, about 2200 feet; the Piedmont Plateau surface south of the Blue Ridge, from 1100 to 1300 feet. An exception to this variation from river to river is the plateau of the Blue Ridge, most of which is between 3200 and 3300 feet . . . . The plateaus of Pigeon and French Broad rivers belong to the same period of erosion. The Blue Ridge plateau represents a much earlier and much longer period. Southeast of the Blue Ridge the great Piedmont Plateau was formed at a still later period of erosion, whose action has not yet produced similar features on the streams which drain into the Mississippi. The streams southeast of the Blue Ridge have shorter courses tc the Atlantic and have been able to establish lower grades clear to their headwaters."

In this account the Blue Ridge summit peneplane is oldest, the Asheville intermediate, and the Piedmont the youngest. The Blue Ridge escarpment is thus the topographic break or slope between two peneplanes formed during different cycles of erosion.

E. Theory of two peneplanes of the Same Age

Davis[7] has described especially well the nature of the Blue Ridge escarpment and has shown that it is a westward retreating divide due to the uneven contest of streams. The problem of the origin of the scarp is specifically treated in these sentences:

"In the Blue Ridge . . . . the migrating escarpment is essentially independent of structure: it is carved in a body of heterogeneous and disordered crystalline schists whose variation in resistance to weathering has only a secondary influence on the elements of topographic form here described: the escarpment seems to me to be due largely to the simple fact that the land surface is degraded to a lower

[6] Arthur Keith; Pisgah Folio, No. 147, U. S. G. S. (1907).
[7] *Loc. cit.*

level by the short rivers of the Atlantic system than by the long rivers of the Mississippi system. The basis of the two systems 'break joint,' as it were, and the Blue Ridge is hereabouts the slope by which the discordant floors of the two basins are connected. It seems manifest that neighboring peneplains, eroded by river systems of different length, must stand at unequal height along their line of contact; that a relatively well-defined escarpment must separate the two plains; and that active retrogressive erosion must take place on the escarpment."

As an additional factor in maintaining the higher elevation of the mountain peneplanes, he says,

"The occurrence of resistant rocky barriers on the course of the longer river system would certainly conspire with excess of length to maintain the headwater basins at a higher level than those of neighboring shorter river systems, on whose course fewer hard-rock barriers might be expected; and in the case in hand, there is good reason for thinking that this additional cause is operative."

This author does not state fully the case in regard to the number of erosion cycles but, as indicated above, stresses the importance of differences in distance to the sea and the presence of rocky barriers in determining the altitudes of neighboring erosion levels. As will be seen in the later discussion, these causes are regarded as important. The present writer, however, follows Keith in discriminating between the Blue Ridge summit and Asheville peneplanes.

F. Theory of superior rock resistance

Because of the close similarity of the rocks underlying the Piedmont and Older Appalachian Mountains it has generally been assumed that the greater elevation of the latter could not be due to any large extent to the greater resistance of the rocks. The writer does not propose it as a single cause for the Blue Ridge, but wishes to call attention to the importance of contrasts in rock hardness in Appalachian topography. As one drives along the axis of the Great Valley through Virginia and Tennessee the western slopes of the Older Appalachians rise almost as abruptly above the floor of the Great Valley as the Blue Ridge rises from the surface of Piedmont. It is, truly, not quite so much like a wall with a drainage divide on its top, but the front is almost as imposing. In many places its stream emerge from high-walled rocky canyons carved in quartzites and pass out to the

open limestone valley. The prominence of the western front is unquestionably due to hard rock and it is believed that this cause has wide application in the entire area.

HISTORICAL SUMMARY

A complex, crystalline mountainous area on the east was bordered on the west by folded mountains; the entire region was exposed to long stream erosion which resulted in general peneplanation, somewhat less perfect in parts of the complex area where great monadnock masses were left standing two thousand feet above the peneplane. This extensive surface was uparched and upwarped along axes of uplift to higher elevations in the central western part of the crystalline belt, and lower elevations to the east and west, thereby establishing a divide; the soft rock belts, including the Great Valley, and strips in the crystallines, west of the divide, and the area on the east drained by short Atlantic streams, were baseleveled again, while the remainder of the area was maturely dissected. The region was uplifted with slight warping, and dissected to depths varying from almost nothing at the heads of the broad baseleveled valleys in the highlands, to more than three hundred feet along major streams.

In this account three cycles of erosion are involved. The oldest cycle is represented by the Blue Ridge summit peneplane and monadnocks; the second, by the Appalachian Valley peneplane, the Asheville and other high-lying, local peneplanes, as well as the Piedmont, and by monadnocks rising above these surfaces; the third, by the young to mature valleys cut by streams in the present cycle. The writer does not overlook the presence of stream gravels and rock benches between the lower peneplane surface and the present stream levels in the Appalachian Valley and Piedmont, but they seem to indicate pauses of brief duration, not comparable to the long cycles represented by the major topographic features.

In view of the uncertainty as to the date of origin of the higher peneplane, usually assigned to the Cretaceous, the writer prefers to use the term Upland until more evidence is available to justify

a specific place in geologic chronology. In like manner the term Valley peneplane is regarded appropriate for the erosion surface in the Appalachian Valley. The Asheville level is better known than any other highlying local peneplane and will be referred to as the type of this group. The name Piedmont peneplane is thoroughly understood.

The point of especial emphasis in this paper is the suggested correlation of the Valley, Asheville and Piedmont peneplanes. Brief descriptions of the Upland peneplane, and the lower ones just mentioned, are presented, followed by a statement of the basis for the proposed correlation.

UPLAND PENEPLANE

The Upland peneplane is extremely well developed all along the Blue Ridge summit and adjacent upland through the southern part of the Hillsville quadrangle, where it has an altitude of approximately 3000 feet. The monadnocks are few and relatively inconspicuous. From all points in the vicinity of Mt. Airy in the Piedmont, the scarp presents an even skyline. Passing toward the southwest it rises, until in the vicinity of Grandfather Mountain its elevation is from 3800 to 4000 feet. Here the monadnocks are numerous and massive, and at many points they dominate the topography to such an extent that remnants of the peneplane are difficult to locate. In the Mt. Mitchell district these monadnocks and the high-lying local peneplanes of North and South Toe Rivers and Cane Creek are the most important elements in the topography. From the summit of Sunset Mountain, three miles north of Asheville, one can see traces of the level to the south and west, while from Jumpoff Mountain west of Hendersonville it is much better shown at approximately 3200 feet to the south and southeast. The preservation of this Upland surface is even more perfect near Lake Toxaway, North Carolina, and Caesar's Head, South Carolina, as described by Keith in Folio 147 of the U. S. Geological Survey. The altitude at the last locality is approximately 3100 feet and monadnocks are relatively few. The remnants of the higher peneplane are best preserved around the heads of such streams as the tributaries of

New and French Broad Rivers which enter from the south and east. Its topography is rougher than that of the lower levels and monadnocks are much more abundant. Stream gravels associated with it are deeply weathered and decayed. The writer has not examined the Unakas, and is not prepared to say whether or not the "balds" there form parts of the Upland level.

VALLEY PENEPLANE

The Valley peneplane is very splendidly developed on the limestone and shale rocks of the Great Valley. In the vicinity of Newport, Tennessee, near the junction of the French Broad and Pigeon Rivers, it has an altitude of 1200 to 1300 feet. It ranges up to approximately 2600 feet on the divide between New and Tennessee Rivers near Wytheville, Virginia. Although it is dissected to depths of over 200 feet, its remnants still indicate a very even erosion surface. An especially good preservation of it is found in the territory called "The Knobs" just north of Newport.

ASHEVILLE PENEPLANE

The Asheville level extends for some forty miles along the French Broad River from Marshall, by Asheville, on to Brevard and Rosman. It is interesting to note that it is much more extensively developed around Hendersonville along tributaries of the French Broad than in the main valley nearby. The width of the belt ranges from several miles up to ten or fifteen. Its altitude along the French Broad varies but slightly from 2200 feet. It is a little below 2200 feet between Marshall and Asheville while at Brevard it stands at approximately 2230 feet. The depth of dissection at Asheville is more than 200 feet, at Hendersonville about 100 feet, and at Brevard from 50 to 75 feet. Since all three cities are built on the dissected peneplane it is easy to understand why Asheville is more hilly than the others. Stream gravels are found at many localities on its surface. The photograph of this basin, reproduced in plate LXXIX, shows the rimming mountains in the distance, and the entrenched French Broad River in the middle ground.

The Asheville is the largest and most typical example of a series

of local, high-lying peneplanes developed along the stronger streams of the mountain belt where they flow on rocks of only moderate resistance. They are long, narrow strips whose remnants merely indicate broad mature valleys in the former cycle. Many are too narrow to be called true peneplanes. But they are unquestionably of the same age and origin as the Asheville. Several examples will be described briefly at this point.

The Valley erosion level stands about 2300 to 2400 feet above sea where New River breaks through the last hard rock barrier of the crystallines in its journey toward the northwest. Just above the barrier the local peneplane occurs at 2500 feet, and rises through the Hillsville and Wytheville quadrangles to 2800 feet at the junction of the North and South Forks of New River. The magnificent meanders of the South Fork in the northwestern corner of the Wilkesboro quadrangle are entrenched in an erosion surface at 3000 feet, while the same surface is maintained at 3300 feet just east of Boone, North Carolina, and at 3500 feet along Middle Fork of South Fork. The upper Linville basin at the Village of Linville, southwest of Grandfather Mountain, stands at 3800 feet, at Altamont 3300 feet. The upper South Toe, east of Mt. Mitchell, preserves its former baselevel at 2900 feet, but it slopes down to about 2500 feet where it joins the North Toe. From this point the North Toe level slopes upstream to 2800 feet east of Sprucepine, where it forms a broad basin just west of the scarp. The Asheville level is continued eastward from Asheville up the Swannanoa River to an elevation of more than 2400 feet near Black Mountain village, while Hominy Creek, entering the French Broad from the southwest near Asheville, carries its erosion surface to the same altitude near the Buncombe County line. The upper Pigeon basin near Canton, in the southwestern corner of the Asheville quadrangle, and the basin of Little River near Cedar Mountain postoffice, Pisgah quadrangle, maintain elevations of 2800 feet.

PIEDMONT PENEPLANE

The Piedmont peneplane is perhaps the best developed and best preserved extensive erosion surface in the eastern United

States. Excepting several massive ridges, such as South Mountain near the base of the Blue Ridge, monadnocks are relatively few. They are frequently conical features like Pilot Mountain, west of Winston-Salem, but some are ridge-like. There are many places in the Carolina Piedmont where the horizon is unbroken by erosion remnants. It is a grandly sweeping even surface as viewed from the Blue Ridge crest and at one point the local residents have styled it "Ocean View." The stage of dissection varies from submature to early mature, and the streams have cut as deep as 200 feet below its surface. Interstream areas are moderately dissected with many drainage slopes, and only occasionally are they relatively flat. A typical view is shown in plate LXXX. From elevations of 1200 to 1600 feet along the base of the Blue Ridge it slopes gently to the southeast. At numerous localities water-worn gravels were found on its surface.

The proposed correlation of the Valley, Asheville and Piedmont peneplanes is based on a consideration of the following lines of evidence: (1) extent of development, (2) degree of dissection, (3) elevation above sea level, (4) water-worn gravels, (5) drainage lines.

EXTENT OF DEVELOPMENT

The Valley peneplane is developed in the limestone and shale belts of the Appalachian Valley, and in similar soft-rock valleys among the Alleghany Ridges. Its width and extent are sharply limited by the distribution of soft rocks. Where sandstone formations outcrop in the Valley they determine ridges, and where the limestone contains cherty members there are low monadnocks. The most perfect development of the surface is found in areas underlain by shale which is more uniformly weak than limestone.

The Piedmont peneplane is widely developed throughout the area which gives it its name. Since there are many different types of crystalline rocks involved, many of which are supposedly resistant, it would appear that this level represents a longer cycle than the one in which the Valley peneplane was formed. In this case only the softer rocks were baseleveled. There are at

least two causes which contributed to this result. Hayes and Campbell stated that the Cretaceous and Tertiary levels come so close together near Atlanta "that their peneplains cannot be discriminated." It was their view that a steep slope on the upwarped surface led down to what is now the Piedmont so that the two peneplanes practically coincide in the western portion of Piedmont. Today it is believed by some[3] that the intersection is along the fall line. Nevertheless, it is obvious that since the Upland or Cretaceous surface sloped down toward the east the thickness of rocks to be removed during the next cycle in order to produce a peneplane would be less than in the mountain belt where the Valley level is at least 1000 to 1500 feet below the Upland. Because of the fact that this surface is entirely erased from the Piedmont it is impossible to do more than merely suggest its probable importance. The second factor is the great contrast in the distance to the sea as proposed by Davis. These short Atlantic streams were more effective in developing a baselevel than those that traveled perhaps five times as far to the Gulf. These two possible causes for the more perfect development of the Piedmont surface may, when combined, constitute an adequate explanation.

The extent of development of the Asheville and related levels is not conditioned by the distribution of rock types. From a study of the geologic maps and the topography it is evident that the different phases of a single formation must have a considerable range in resistance to erosion. But in any event, when the Asheville basin is studied in relation to the bold mountains which form its rims there can be only one conclusion as to the relative hardness of the rocks. The width of these local peneplanes varies from a fraction of a mile to fifteen miles. Many represent merely former mature valleys, others, presumably on softer rocks, have opened out wide basins. Those streams or parts of streams which show no traces of these high levels have found too stubborn a resistance in the underlying rock.

With reference to the perfection of the three levels there is much

[3] Geo. T. Renner, Jr.; The Physiographic Interpretation of the Fall Line; Geographical Review, 17, 278–286 (1927).

less variance than in the matter of extent of development. The accordance of hilltop, in the Asheville area, and the presence of only an occasional low, conical monadnock, can be duplicated in many places in the Valley and in the Piedmont. The Asheville is barely less perfect, if any, than the Piedmont, and perhaps slightly better developed than the Valley peneplane where the limestones are appreciably cherty.

DEGREE OF DISSECTION

It was the degree of dissection along with the perfection of development that first attracted the attention of the writer to the remarkable similarity between the Catawba and Asheville basins. The Catawba River is mature, while the French Broad is younger, as will be seen by comparing plates LXXXI and LXXXII. Altho the streams show a difference in stage of development the depth of entrenchment and extent of dissection of interstream areas are more nearly the same. The accordant hilltops are about 200 feet above stream level, and no extensive flat surfaces are preserved. Near the heads of the stream basins in the Blue Ridge country the depth of cutting is less than farther downstream. It is a striking fact that as one goes up the New River valley the erosion surface rises a thousand feet, but the hills which preserve it rise uniformly 200 to 250 feet above the stream, until the head is approached. Similar conditions hold in all the basins of the mountains where there was baseleveling in the cycle just preceding the present.

The Catawba basin is being used as a typical example of the Piedmont area near the Blue Ridge. It should be understood that the topographic features exhibited there are not essentially different from those at other points. Its selection is due primarily to the fact that it is geographically nearer the Asheville area than other basins and it thus affords a fairer comparison. The dissected level of this River from Morganton, on to Marion and Old Fort is so similar to areas of the Valley peneplane in some of the broad valleys among the Alleghany Ridges near Covington and Clifton Forge, Virginia, that one cannot easily discriminate between the topographic features of the two regions. A photo-

graph of a strip of this surface is shown in plate LXXXIII. In like manner the hills bordering an entrenched meander of New River, which were dissected out of its former level, are shown in plate LXXXIV.

It is a matter of interest to note that the artificial lakes of the region are located in dissected Tertiary (?) districts. Lake James, in the Catawba basin, and Lake Lure on the Broad River near Chimney Rock, are in the Piedmont. Lake Junaluska, in the mountainous upland, has been recently formed by damming Richland Creek, a tributary of Pigeon River near Tuscola, in the southwestern corner of the Asheville quadrangle. Lake Toxaway, farther south (now drained), illustrates the same thing. Their deeply indented shorelines, caused by dissection before the dams were built, and the evenness of the surrounding hills, mostly forested, conspire to make them quite beautiful.

These three levels are the last important erosional features produced in their respective regions, prior to the present cycle with its minor pauses and interruptions. To assign any one an earlier date would raise the question as to what happened in that area during the later cycle when the others were formed. If, as has been frequently done, the Asheville be regarded as an older level and the Piedmont and Valley as younger, we must find some evidence in the Asheville basin of the erosion which, in the Valley and Piedmont areas, produced extensive peneplanes. It apparently shows no such evidence. The French Broad at Asheville is younger than it is near Newport, and younger than the Catawba. It is inconceivable that a cycle of erosion in addition to the present has transpired since the French Broad began to dissect its magnificent peneplane.

ELEVATION ABOVE SEA LEVEL

It is doubtless because of their relative elevations that the Asheville peneplane has frequently been assigned to an older period than the Piedmont. When the various levels of the group of local peneplanes represented by the Asheville are examined we find that they range from 2200 to 3800 feet. These levels were doubtless affected by warping, but the prime cause of the varia-

tion seems to lie in resistant rock barriers athwart their courses. They are a series of temporary baselevels. The Piedmont along the Catawba at Old Fort is approximately 1600 feet above sea.

The Valley peneplane rises from 1250 at Newport to 2600 on the divide near Wytheville. It is there 400 feet higher than the Asheville. The relation between the Asheville and Valley peneplanes is most clearly shown in the New River basin. The Valley surface is around 2400 feet where the New River enters the limestone area. Just within the crystalline belt the local level occurs at 2500 feet and it rises to 3500 feet near its head. The broad baseleveled valley of New River in the crystallines coalesces with the Valley peneplane. There seems to be little doubt as to the unity of history there. The high altitudes of the mountain levels require no further explanation, it seems to the writer, than the presence of rock barriers of varying degrees of resistance and width. The Valley peneplane at Newport is 350 feet below the level of the Piedmont on the opposite side of the Blue Ridge at Old Fort. The three factors of rock resistance, rocky barriers and distance to the sea combined with differential uplift seem to be quite adequate to account for the differences in elevation among this group of erosion surfaces.

WATER-WORN GRAVELS

The writer has examined the stream gravels on the surface of the Valley peneplane where it is very typically developed in shale country in Virginia.[9] In the valley of Craig Creek near Covington, well-rounded, but pitted, gravels were found on the accordant hilltops which there preserve the Valley level at 1250 feet. The pitting, which indicates considerable weathering since rounding, readily distinguishes them from the smooth gravels of modern streams. The writer has also described some gravels of apparently much greater age from the upland along the scarp of the Blue Ridge in the Hillsville quadrangle.[10] These boulders

[9] Wright, Frank J.; The Physiography of the Upper James River Basin in Virginia; Bul. 11, Virginia Geol. Survey, 32 (1925).

[10] Wright, Frank J.; Gravels of the Blue Ridge; Jour. Sci. Labs. Denison Univ., 22, 133–135 (1927).

and gravels are deeply weathered and frequently broken, as shown in the photograph reproduced along with the description. Their position is above the lower peneplane and they have been tentatively assigned to the first cycle. They are older than those found on the Valley peneplane in Virginia. At scores of localities in the Piedmont, and at almost as many in the various basins of the Older Appalachians, the writer found gravels of apparently the same age as those in the Valley. They are mostly of quartz and quartzose material and show considerable weathering as indicated by their pitted surfaces. They are intermediate in age between those of the present streams and those on the upland of the Blue Ridge. Among the more accessible localities where these gravels occur are the hills around Asheville and Brevard, and on the Piedmont hills of the Catawba Basin. The surfaces of the three peneplanes have gravels which show approximately the same degree of weathering.

DRAINAGE LINES

Some of the main streams in the three regions under comparison have entrenched meandering courses. The New River has a large number of excellent second cycle meanders in both the Valley and crystalline areas. The photograph shown in plate LXXXV indicates its entrenchment, while plate LXXXIV shows an incised meander. It is very similar to the French Broad as seen in plate LXXXII. The streams of the Piedmont have more open valleys and entrenchment is less obvious, but it shows in places along the Catawba and other streams. Excellent entrenched meanders are found in the Appalachian Valley as, for example, on the Shenandoah River.

TENTATIVE CONCLUSIONS

In view of the similarities described above the writer is of the opinion that the Valley, Asheville, and Piedmont peneplanes were all formed in the last complete cycle preceding the present.

It is believed that the solution of the problem of the Blue Ridge is to be found in the physiographic history of the region. The Upland peneplane along its summit is regarded as older, the

Piedmont as younger, and the scarp between them as the dissected margin of the upper level. Contrasts in rock resistance, and rocky barriers have been important in determining the extent of development and altitudes of the Valley peneplane and the group of high-lying local peneplanes in the upland of the Older Appalachians. Proximity to the sea has been a factor in the perfection of the Piedmont, but great contrast in stream length, between Atlantic and Gulf drainage, did not offset the contrast in rock resistance as shown by the fact that the Piedmont peneplane is 350 feet higher than the Valley peneplane on the opposite side of the highlands. Differential uplift was certainly responsible for the acceleration of some streams and the retarding of others, and was probably largely responsible for the position of the Atlantic-Mississippi divide. It may also have conditioned the amount of erosion required for the peneplanation of the Piedmont in the second cycle.

PLATE LXXVI

BLUE RIDGE SCARP LOOKING SOUTHWEST FROM HIGHWAY TEN MILES NORTH OF MT. AIRY, N. C., SHOWING TAPERING SPUR IN THE DISTANCE

PLATE LXXVII

LOOKING NORTHEAST ALONG BLUE RIDGE THREE MILES EAST OF LOW GAP POST OFFICE, HILLSVILLE, VA.-N. C. QUADRANGLE

PLATE LXXVIII

THE PIEDMONT PENEPLANE JUTTING INTO THE BASE OF THE BLUE RIDGE; FROM HIGHWAY BETWEEN ROANOKE AND ROCKY MOUNT, VA.


2


3

PLATE LXXIX

Asheville Peneplane, Looking West from Gooch Peak. Near Asheville, N. C.

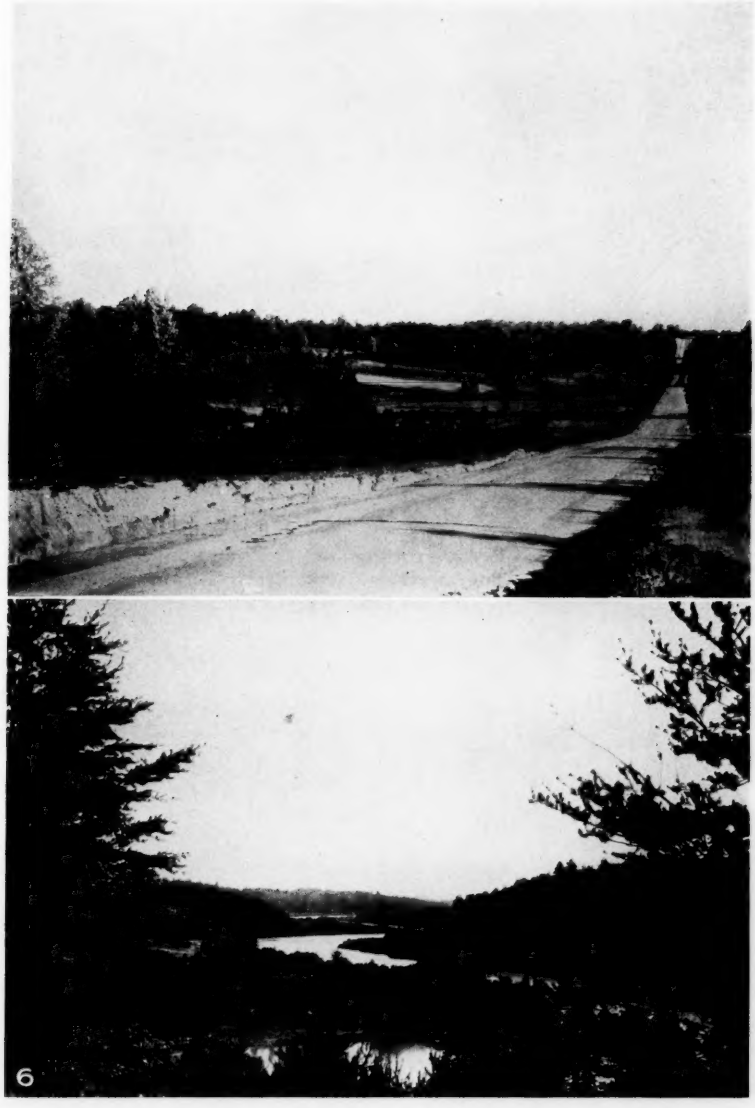
(Courtesy A-B Photo Service, Asheville, N. C.)

PLATE LXXX

THE PIEDMONT, SEVERAL MILES SOUTH OF WINSTON-SALEM, N. C.

PLATE LXXXI

CATAWBA RIVER, TWO MILES NORTH OF MORGANTON, N. C.



6

PLATE LXXXII

THE ENTRENCHED FRENCH BROAD RIVER, TEN MILES NORTHWEST OF ASHEVILLE, N. C.

PLATE LXXXIII

FLOODPLAIN OF CATAWBA RIVER, WITH WOODED HILLS REPRESENTING DISSECTED PIEDMONT; SIX MILES SOUTHWEST OF MARION, N. C. HICKORYNUT MTS. IN THE DISTANCE

7

8

PLATE LXXXIV

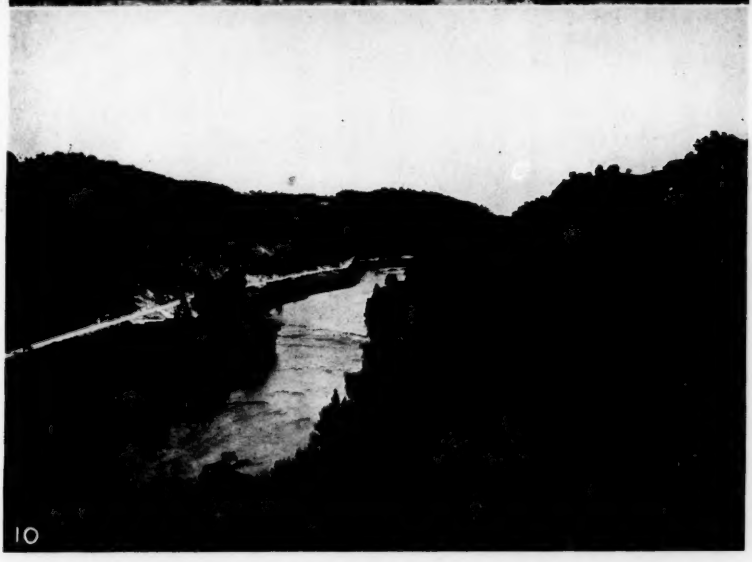
ENTRENCHED VALLEY OF NEW RIVER, SIX MILES NORTH OF DEEP GAP, CRANBERRY, N. C.-TENN. QUADRANGLE

The wooded hills preserve the local peneplane at 3100 ft.

PLATE LXXXV

THE NEW RIVER, FOUR MILES EAST OF JEFFERSON, N. C. A STRAIGHT STRETCH BETWEEN MEANDERS


9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